Bringing Hard Science to 4-H; Creating a new 4-H project

Honors Thesis (HONR 499)

by

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Abstract

The goal of the 4-H program is to help youth grow and develop in all areas, but they are lacking slightly in the STEM activities they offer. This project seeks to fill that gap by creating a series of chemistry activity books which can be implemented as a new 4-H project. With the adoption of these books, the 4-H program will have its first purely scientific project to offer its members. The activity books cover grades 3 through 11, the typical age range of most 4-H projects and provide participants the opportunity to learn more about science. The books also encourage 4-H members to explore chemistry in the world that surrounds them, inspiring curiosity. The books provide a structure for learning complex chemistry topics, but leave enough freedom that participants may explore the topics with curiosity and interest.

The books are structured in a similar manner to current 4-H books for ease of adoption and incorporation into the 4-H program. The activities are organized by topic which are repeated in subsequent levels in greater detail and complexity. By revisiting the topics with different activities and experiments, students are provided with the opportunity to learn the same concept in a variety of ways. This iterative process reinforces the concept knowledge so that it is better understood.

Acknowledgments

I would like to thank my family; Tom and Kelly Kuchenbrod, Debbie Funk, and Michael Spivey for supporting and encouraging me in this endeavor.

I would also like to thank the Ball State Chemistry Department for the experiences and opportunities.

Author's Statement: Bringing Hard Science to 4-H; Creating a new 4-H project

The 4-H program was an immense part of my childhood; it made me who I am today. This program taught responsibility, determination, and time-management. 4-H had such a major impact on my life that I recruited my two best friends and my five younger cousins to join because I wanted everyone to experience its benefits. I enjoyed the fair and the projects so much that after my first year, when I took seven projects (as a third-grade student), I never again took less than 10 projects. My tenth and final year of 4-H involved completing 32 projects. Even while juggling school and other extra-curricular activities, I always made time for 4-H. Since my final year, I have wanted to give back to the 4-H program, "to make the best better" ("4-H Motto") as is the 4-H motto, and help the program grow the way it helped me grow.

I wanted to create a chemistry project for the 4-H program to benefit both the program and the members. During my ten years of 4-H, I completed a wide variety of projects ranging in topic from livestock to scrapbooking to recycling. However, in those 10 years, I was never introduced to any hard science, such as chemistry. Projects currently offered by the 4-H program include: aerospace, which occasionally mentions physics (though the bulk of the project is based on model planes and rockets as opposed to true physics or astronomy topics); vet science and wildlife, which often touch on simple biology topics; and geology, which focuses on Earth Science. But rarely did any of these projects mention chemistry, or cover the topics in depth.

As a child, chemistry was always exciting. Chemistry sets frequently made appearances under the Christmas tree, so it always seemed it would be fun to combine my interest in chemistry with my near obsession with 4-H. Eventually, I was able to incorporate chemistry into some independent study projects that are reserved for only the senior level members, typically the tenth and final year of 4-H. However, by creating a new project through this thesis, one based entirely on chemistry, I hope to provide future 4-H members with an opportunity that I did not receive but would have enjoyed.

Current 4-H STEM based projects are actually resulting in an increase in participation in these fields, despite the lack of any projects which are focused purely on science. According to an 8-year study performed by Tuft University, partnering with 4-H, children who participate in 4-H are twice as likely to participate in STEM activities, compared to those who do not participate in 4-H ("Proven Results"). This fact confirmed the need for just such a project as this, since 4-H members would be a sensible target audience for a new chemistry activity book.

Additionally, according to the 2015 Annual report published by the National 4-H Council, in the year 2015 there were nearly 6 million children who participated in 4-H. This number demonstrates that if successful, this project would reach a large audience and have a larger impact than the simple creation of another an activity booklet for kids. It was surprising and exciting to learn in the 2015 Annual Report that only 43% of 4-H participants are from rural areas. 4-H is often thought of as nothing more than a county fair for farm kids, but the reality is that the majority of 4-Her's are from suburban or urban areas ("National 4-H"). This information demonstrated that this new 4-H activity book would definitely reach a wider demographic.

As this project evolved, an overriding goal and focus had to be that the project be practical to implement. First and foremost, the activities had to be safe for students of all ages to perform in their homes with only minimal supervision required. The next priority was that the chemicals required for the experiments had to be inexpensive and easy to obtain. Additionally, the activities had to be simple enough to be understood by students who had not yet been introduced to chemistry but also engaging enough to be enjoyed by the students who already had some science background. Finally, the structure of the project had to resemble the 4-H projects that are currently available in order to reduce confusion among members who would be participating in this project and are already familiar with other, current projects.

To achieve the first two criteria, I decided to use primarily household chemicals for the activities outlined in the project. Using household chemicals, such as vinegar and baking soda, would insure that the activities were both safe and inexpensive. While it is impossible for all the chemicals used to be completely harmless, they were all at least safe enough to be stored in the average home on a regular basis. This also meant that the chemicals would be inexpensive and easy to obtain; all could be found at a typical grocery store or pharmacy. This had the added benefit of encouraging students to see the potential in the things that surround them.

By using chemicals found in the home, I hope students will be encouraged to ask questions. I want kids to look at the world around them with curiosity, so by helping them to investigate one aspect of their environment, I hope they will begin to explore other topics as well. The activities in this book will encourage them to think and question deeper than they might otherwise. My hope for this project is that it will prompt students to ask questions, such as: How does soap remove dirt, why does salt prevent roads from becoming icy and slick, why does carbon dioxide cause rain to become acidic, and why do leaves change color in the fall? Science grows and moves forward when people ask questions. I want to instill curiosity in 4-H members who participate in this project to help them grow as individuals and to hopefully, one day, help the field grow as more people become interested in science.

The curiosity I hope to instill in the participants is also a useful tool in creating activities that are both challenging and engaging. Many of the activities I created for this project end with a challenge to investigate the concept or experiment further. I wanted to encourage students to go beyond the minimum requirements and continue exploring topics that interest them. I want students to ask questions and have a desire to learn because nothing is as beneficial as hands-on experience and slef-motivation. The 4-H program, too, advocates that students and members "learn by doing" which is specifically the program's slogan ("4-H Motto").

Instilling curiosity will increase the students' interest in the topics. However, it is still necessary that the activities are able to be understood by those students who have little or no background in science and are still interesting to the students who have a stronger science background. According to the Indiana Department of Education's website, chemistry topics are not required subject matter until 7th grade (Indiana). These project activity books are targeted at students as low as 3rd grade. Therefore, the majority of beginning students most likely will not have a strong science background and it will be necessary to explain topics in much more detail for these lower levels. To accomplish this, the topics are explained in easy to understand language, rather than technical jargon that the students might not yet understand, and the topics are presented and explained using comparisons to their everyday lives. Where possible students are encouraged to explore the topics independently so that they will discover the information themselves, which inevitably leads to a better understanding of the material.

The final goal of the project, a parallel to current 4-H projects, was achieved in the structure and design of the project books. Each book contains a few activities for the 4-H members to complete each year, and prompts them choose and complete an independent activity on their own. The predesigned activities provide a structure and a path for the members but the independent activity gives them the freedom to explore a topic of their own choosing. The activities themselves are structured in such a way that they first provide the necessary background information, and then explain the instructions for the activity to be completed. Each activity concludes with questions meant to stimulate critical thinking. The final year is also left as an independent study. This freedom of topic allows mature students to explore their own unique interests, rather than be confined to the activities of the book and follows the already established structure and familiarity of most other 4-H projects.

In order to create the activities, a few of the most important topics were chosen using my high school chemistry notes to determine which topics appeared most frequently or were covered in the greatest depth. I then thought about chemistry experiments I had performed as a child and how they could be adapted to be performed in the home. The necessary information is then presented to the students in a way that maximizes the effectiveness of the activities as a whole.

The activities needed to be both challenging and engaging. The information could not be dull or present like a textbook, but was necessary to insure the student did not miss the significance of the activities. Without the corresponding information, the activities are fun, but they aren't informative. Balancing these two components was challenging at times, but relating the information to things they see around them every day made it easier. Information is more easily understood if it can be related to an already known concept. The connections made during the learning process equate to connected synapses and result in a better understanding of the concept. These connections are strengthened when a topic is revisited. Covering information more than once also results in a better retention and deeper understanding.

The students need to revisit topics and explore them in greater depth as their understanding of chemistry grows and they mature. Frequently, in activity books such as these, even in most of the current 4-H books, topics are mentioned and explained once but never again. By doing multiple iterations of these activities, students will have the opportunity to gradually understand the concepts more fully and relate them to the world around them. With a large number of unrelated activities, it is often difficult to see the relationship between what is being learned and how it can be applied on a larger scale. However, by explaining the concepts and relating them to increasingly complex experiments, students will hopefully see the applicability of the information they are learning. Student so often ask "When will I ever use this again?" With this progressively more complex topic repetition, it should be fairly obvious to them that they will indeed use this information again, and that it will be valuable to them in the future. This reinforcement of learning science, and specifically chemistry, is the biggest difference between these activity books and the many that have come before. The topics are not presented in a "one and done" manner, but rather they build on themselves, and will be applied in future activities.

However, should a student chose to pick up this project in their later years of 4-H, the information is still present so they can succeed without having taken the project from the beginning. This allows them the flexibility to try new things without a fear of failure, as is often the greatest obstacle students face. Students often fear trying new things because they worry about doing poorly and being judged for their short comings. Hopefully this fear will be alleviated by explicitly expressing to the students that a mistake is not failure, it is an opportunity for growth. Countless scientific discoveries have been the result of a mistake or an unexpected outcome. Additionally, when asking students to state their hypothesis, it is clearly explained that a hypothesis is simply a guess, albeit it an educated one, based on research and prior knowledge. However, it is still not a guarantee or a final answer for which they will be judged. It is simply an opportunity to apply the knowledge toward predicting what they think might happen. If their hypothesis is wrong they are encouraged to do more research, then repeat the experiment. After all, the basis of science is reproducible results, so performing the experiment again gives them the chance to see that science is predictable and consistent.

The original intent for this project was to create a single book of activities for only the youngest age-group of students, to peak their interest early in the hopes of encouraging them to explore the topic of science on their own. But it was quickly realized that the creation a single book would only draw them in but then leave them wanting more as they matured. However, my goal is to challenge them, motivate them, and help them grow. The result was three individual books that span all three age divisions of the 4-H program, meaning they could take the project every year. This evolving project resulted in a much better and more comprehensive product and I hope that it will prove highly beneficial as a starting point for STEM when adopted.

My final goal for this project is to see it through to eventual adoption by the 4-H program. I have already spoken with the program director of Spencer County (the county where I was a participant as a child) who has agreed to work with me in the coming years to implement my project at this fair on a trial basis. Over the next two or three years I will review the results of this trial and make any necessary changes. I will then contact the 4-H program leaders for the state of Indiana and eventually the National 4-H Council. I will work with 4-H leaders and participants to constantly improve the project so that it may one day reach students across the nation, stimulating curiosity and critical thinking. I hope to improve the 4-H program so that it meets the needs and desires of every student as well as help the field of science grow as a new generation is encouraged to examine the world around them.

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Chemistry at Home

Level 1

IMPORTANT

Note to the Project Helpers

As the project helper for this project you will be the lab assistant. You will be responsible for supervising tasks that may not be suitable for younger children to perform totally on their own (such as using a stove). None of the experiments in this book are inherently dangerous but if instructions are not followed properly, they may become dangerous. That being said, make sure to use your best judgement when dealing with chemicals. For example, if a chemical has a strong or noxious odor move the experiment outside or to a well-ventilated area. The chemicals produced by the experiments will also be safe enough that they will not require special disposal. All chemicals can be poured down the drain and flushed with running water.

When using chemicals, make sure to follow all safety procedures provided by the manufacturers. Some chemicals may be slightly different in composition based on brand so be sure to follow the instructions they provide as all of these differences cannot be accounted for in the design of the experiments.

Safety equipment, especially eye protection, is recommended for all experiments involving chemicals. Some chemicals used may also be irritating to the skin. If contact with any chemicals occurs, follow the manufacturer's instructions for cleaning the area. Typically flushing the area with cold water will be sufficient. Some chemicals may also stain clothes, so a lab coat may also be desired. Alternatively, the students may wish to wear old clothes when performing some of the experiments. It is best to avoid direct contact with the chemicals unless you know it is safe to have contact with them.

The chemicals required for these activities can all be found at a typical grocery store or pharmacy. You should never need to purchase high grade, expensive, or toxic chemicals for the experiments. Some experiments require equipment such as a thermometer, scale, and stopwatch.

Note to the 4H member

This project will demonstrate a few basic chemistry topics. Each subsequent level will cover the same topics in greater detail as you progress.

The activities are divided into sections based on the topics and purpose of the activities. The Introduction section is purely informational and will be useful in furthering your understanding of chemistry itself. The Describing Reactions section examines the reaction process specifically, rather than a chemistry topic. Chemical reactions are the basis of chemistry and therefore it is important to understand what is occurring when chemicals react. The final section is the Experiments section. These are what one typically thinks of when imagining a chemistry experiment.

Each year you will need to complete one activity from the "Introduction" section, one activity from the "Describing Reactions" section, and two activities from the "Experiments" section. You also need to complete one independent activity, this can be something such as an interview of a scientist, an additional experiment that you have found and want to try, a brief research paper, or some other scientific activity.

Topics for the final display project can be any of the activities from the "Describing Reactions" or "Experiments" sections, or one from of the independent study activities you choose to perform. The project display should be a formal report of the experiment and your data. A formal report typically includes each step of the scientific method: the question to be answered (objective of the experiment), research (basic information on the topic, an introduction to the concept), a hypothesis, an outline of the experiment (the procedure followed), an analysis of the data including charts and graphs, and a conclusion (was the hypothesis correct and what you learned from this experiment).

LAB NOTEBOOK

From a scientific standpoint, it is important to always record the results of any scientific inquiry. This insures that others who look at your data will be able to understand the experiment and learn from your data which helps science, as a whole, move forward.

For this level, the lab notebook has been provided in the form of pages with room to fill out the questions. Feel free to fill out a more thorough lab notebook if you wish. When filling out your lab report be sure to use complete sentences. When forming a hypothesis remember that there are no wrong answers to this question. A hypothesis is simply a guess based on prior knowledge. If your guess is wrong do not be upset, use this as an opportunity to learn and try the experiment again.

Name ______________________________

Project Helper (Lab Assistant) ______________________________

Goals for this Project:

1. ______________________________
2. ______________________________
3. ______________________________

Did you achieve these goals? How?

1. ______________________________
2. ______________________________
3. ______________________________

Activity	Date completed	Project Helper Initials	Independent Activities
Introduction			Description:
Scientific Method			
Periodic Table			
Vocabulary			
Describing Reactions			Date: Helper Initials:
Signs of a Reaction			Description:
Types of Reactions			
Rates of Reactions			
Experiments			
Acids and Bases			Date: Helper Initials:
Chromatography			Description:
Crystal Formation			
Density			
Pressure, Volume, & Temperature			
Temperature			Date: Helper Initials:

Each year complete:

- 1 activity from the "Introduction" section
- 1 activity from the "Describing Reactions" section
- 2 activities from the "Experiments" section

You also need to complete 1 independent activity each year. This can be an interview of a scientist, an additional experiment that you have found and want to try, a brief research paper, or some other scientific activity. Additional notebook pages for these independent study activities have been included at the back of the book.

The Periodic Table

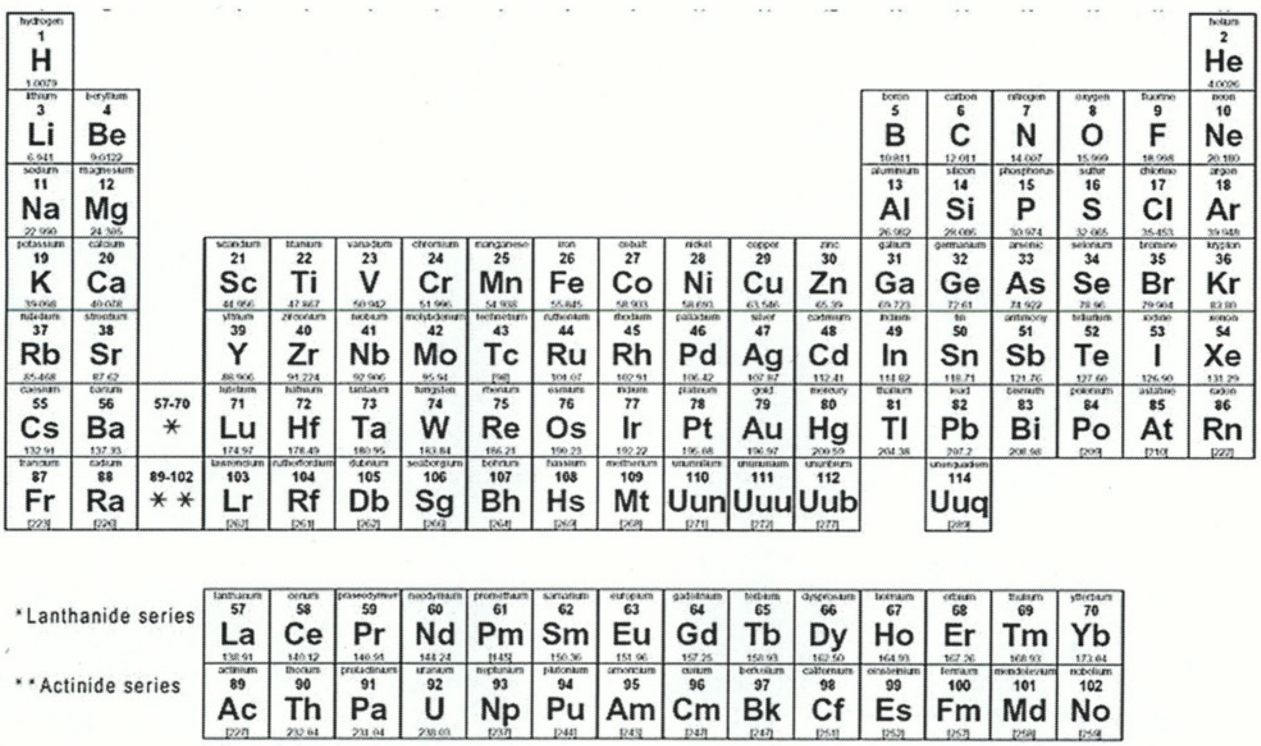
The Periodic Table of elements is an arrangement of the elements that orders them based on atomic number and groups them based on their overall properties.

Atoms are made up of three major pieces: protons, neutrons, and electrons. Protons are positively charged particles, neutrons are uncharged particles, and electrons are negatively charged particles. The number of protons an atom has determines which element it is and is called its atomic number. For an uncharged (neutral) atom, the number of electrons will be equal to the number of protons. The number of neutrons varies but is typically close to the number of protons. Atoms with the same number of protons but different number of neutrons are called isotopes of the same element.

Atoms make up all matter. Every substance is just an arrangement of the elements on the periodic table.

This activity will be a scavenger hunt to see how many different elements you can find in your house. Check off all of the elements from the list that you can find in your home and color them on the periodic table. In the chart give a short description of where you found the element.

In the chart, the number is the element's atomic number, the letters are the symbol for the element, and then the element name. Not all of the elements are listed in the chart, only some of the most common ones. During your scavenger hunt, don't forget about the unseen elements that surround you, such as the oxygen in the air.



1	H	Hydrogen	18	Ar	Argon
2	He	Helium	19	K	Potassium
3	Li	Lithium	20	Ca	Calcium
4	Be	Beryllium	22	Ti	Titanium
5	B	Boron	26	Fe	Iron
6	C	Carbon	28	Ni	Nickel
7	N	Nitrogen	29	Cu	Copper
8	O	Oxygen	30	Zn	Zinc
9	F	Fluorine	40	Zr	Zirconium
10	Ne	Neon	47	Ag	Silver
11	Na	Sodium	50	Sn	Tin
12	Mg	Magnesium	53	I	Iodine
13	Al	Aluminum	74	W	Tungsten
14	Si	Silicon	78	Pt	Platinum
15	P	Phosphorus	79	Au	Gold
16	S	Sulfur	80	Hg	Mercury
17	Cl	Chlorine	82	Pb	Lead

Conclusions:

1. How many elements were you able to find?

____

____

2. In your scavenger hunt, did you find any elements that surprised you?

____

____

3. Were you able to find any elements other than what is listed in the table? If so, what were they? Where did you find them?

____

____

Scientific Method

The Scientific Method is a powerful tool for exploring new concepts, not only in science but in many other subjects as well.

The Scientific Method is a series of steps which promote critical thinking and problem solving. By following these steps, one can explore, in depth, a topic which is completely new or one which has been well studied in the past. The scientific method is flexible enough to be applied to nearly any subject but structured enough to leave little doubt as to how one should proceed with a problem.

Read the steps and then answer the following questions.

Question
- Ask a question, what do you want to know more about? What interests you?

Research
- Find out as much as you can about the topic. What experiments have already been performed and what do the results show you? What additional questions does this research raise?

Hypothesize
- What do you think might be the answer to the question? Is there an experiment you can design to answer the question? What do you expect to happen in the experiment you designed? Why?

Experiment
- Design an experiment, make sure it is safe. Record the specifics of the experiment, the amount of each reactant used and the experiment conditions such as temperature. Perform the experiment and record detailed observations.

Analyze
- Examine the data you collected. Make tables, graphs, and visual representations of the data to help with this. Look for patterns or trends in the data.

Conclude
- What is the significance of the data? Was your hypothesis correct? Did this raise any new questions for you? If your data did not match your hypothesis, use this as further research and repeat the process until you obtain predictable results.

Report
- It is important to always report your results. Communicating your results to others allows them to use it as research when they begin asking questions. Communicating results helps advance science as people can look at the work of others to help them explore new topics.

1. Do you think there should be any additional steps; has anything important been left out?

2. Do any steps seem more important than others? Explain.

3. Could this process be applied to other subjects like a difficult math problem, a confusing literary work, a problem in the community, or any others.?

4. Which step or steps do you think will be the most challenging? Explain.

5. How can you overcome these obstacles?

Try performing the first two steps of the scientific method.

6. What is a topic that interests you?

7. Do as much research on that topic as you can. What did you find most interesting or surprising?

8. Does the information you found raise any new questions? If so, research those as well, learn as much as you can about the topics that interest you so that you can apply this knowledge later.

9. Then, report what you have learned to your lab assistant. It is always important to communicate new information to others so that they may learn as well. Teaching others helps you understand the information better and can lead to scientific innovations as people are able to work together and discover new things.

Vocabulary

D H Y P N B M S H E X M W K O G K H R S Q Z K A Y R W G S F
U E C G R F O R R C U Y N P B S D H E R K N C F H B J N S H
M W N T R L B U Y I K O L D E M C Y A E U Y K I Y O G R K W
P F I S U E T W R P T O P K Z P K R C B Q N W R S G E M L X
U D W T I X N B P O B K F S V E W Z T M O R P G O N W G M G
L P I F I T I E R W K H R C D D H G A U S T C U D O R P W O
J O Y M E L Y P C X Z P Y L I V P O N N H S G D X T N K L N
N K I X I T H L T I S E W O W D L K T C J P C Q I F N T V P
A Q H U G J U F I S T G N S K X Q Z S I S H W E N E P X H L
M N Q T A G S T E M P E R A T U R E I M R M A T T E C Z Z T
Y E A E E C D Z K S X Z N Z S D U E P O D A D I Y U V B W I
Y L A B M S I E H Q Z N B I C P D H M T H Q S R D U L V H Z
Q E M X U S X D P F W I W D K I R A Y A S O L V E N T O B B
A M L B L N O I T C A E R F O E T A R P T Z I Q N N C C S A
Y E A I O O I S Y T Y T N O E O B V C O O I W D H R E N F S
I N C P V Z Z M N G L T E H G S C X P V G T W M Q M Q O F E
P T J X V N K U J O U G G R E A L E I F N O H L A V O R T I
M A S S T S Z V V T F L A H U R R N X T Y K H E R H K T L Z
I T N V W X T Y E I X P T G Z S P W M S F V P M S T A C U V
N O R T U E N H X Z H W I L S H S S S T Q M D L Z I I E I B
S V W I O P U K C Y X P C G L D H E R T U Z R P X U S L C A
X M M X F R O S Z E Z Y W Z L H F C R S R M H N U W A E X W
C C O M T Y Y W M P U G T R Y S T W I P A J H G Y W M W N E
O Y Z C E Y N H P F P Q B O K Y G Z M V I R T X Q K S A Q U
V A R I H T S G Y V N V N L T X B U A P R X B M J A K Q K S
H I P S Q P F T I O R Q X I A T I V E P E K R U S U T B S O
J U F L T M N H E X R W R Z W G O G L L Q R V V Y F Y P V H
R Q B Y Y G F Q N X O A L E V D Q D M V T R H G E N V Z J Z
M Z N L V B F S W M T Z U X G P Z L I M G E X Q D Q J X T W
S X R K I M E V R X P G L B G G U C D C C V F C P I A C O O

*http://puzzlemaker.discoveryeducation.com/code/BuildWordSearch.asp

Find the vocabulary words on the following page.
Use the next page as a glossary of terms if you have questions while performing other activities.

Acid: a substance which releases H^+ ions or accepts electrons when in aqueous solution.
Atomic Number: the number of protons in an atom.
Base: a substance which accepts H^+ ions, releases OH^- ions, or donates electrons when in aqueous solution.
Chromatography: a method of separating a substance into its components by passing it through a medium so that the individual components will travel at different speeds and be separated by their own movement.
Density: equal to mass divided by volume, the amount of mass that occupies a volume of space.
Electron: negatively charged particles which surround the nucleus of atoms.
Element: a substance which cannot be chemically converted or broken down to another substance. Each element is defined by the number of protons in its nucleus.
Equilibrium: a reaction state in which the rate of product production is equal to the rate of the reverse reaction converting the products back into reactants. The reaction will have appeared to have stopped, but the molecules are always in motion and therefore always transforming.
Hypothesis: a conjecture, inference, or theory based on background knowledge but which has not yet been tested or proven.
Ion: an atom that has lost or gained an electron and therefore carries a charge.
Isotope: atoms of an element that have different number of neutrons.
Kinetic energy: the energy of motion.
Mass: the amount of matter that makes up an object or substance. SI unit for mass is grams.
Mixture: a physical combination of two or more substances, with all pieces being visible; example sand in water.
Neutron: neutral particles in the nucleus of atoms.
Pressure: the force exerted on an object by another object with which it is in contact. SI unit is Pascals.
Products: the ending or produced substances of a chemical reaction.
Proton: positively charged particles in the nucleus of atoms.
Rate of reaction: speed at which a reaction occurs, speed at which reactants are consumed or products are produced.
Reactants: the starting substances of a chemical reaction.
Solute: in a solution, the substance which is being dissolved, the substance which is present in a lesser amount.
Solution: a combination of two or more substances with the appearance of being only a single substance. No reaction is occurring; example, salt dissolved in water.
Solvent: in a solution, the substance which is doing the dissolving, the substance which is present in a greater amount.
Temperature: a measure of heat. SI unit is Kelvin (kelvin units are equal to Celsius + 273).
Volume: the amount of 3-Dimensional space something occupies. SI unit is cubic meters.

Rates of Reactions

Some chemical reactions occur very quickly, such as the reaction between vinegar and baking soda, Others take much longer, such as the rusting of a nail. Many things affect the speed of a reaction. Some of the biggest factors in reaction speed are temperature, surface area available for the reaction to occur, and the concentration of the chemicals being used.
This experiment will examine the relationship between surface area and reaction speeds using the reaction of an effervescent tablet and water.

For two chemicals to react, they must be able to come in contact with each other. The more surface available for reaction the faster the reaction will occur. On the diagrams below, use a highlighter to mark the portions of the molecules that would be available for reaction. These are the portions which are not touching another molecule. If the molecule is touching another molecule of the same type it cannot come in contact with the molecules of the other chemical in order to react. For these 2-Dimensional representations this will be the perimeter, for a 3-Dimensional molecule this would be the total surface area. Highlight only the portions which are not touching another molecule.

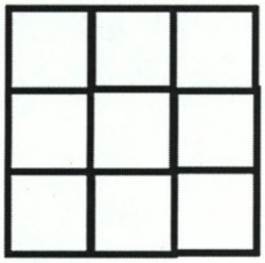


Diagram 1.

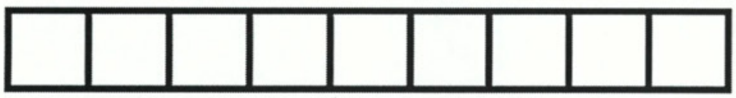


Diagram 2.

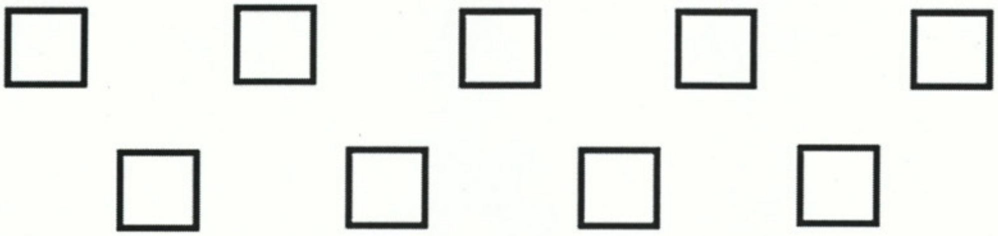


Diagram 3.

Notice that each of these contains the same number of squares but the arrangement affects how much of the molecule is available for reaction. With this in mind, which do you think would react faster when mixed with another chemical, arrangement 1, 2, or 3?

In this experiment, you will be performing the same chemical reaction twice. In one reaction you will use a crushed effervescent tablet and in the other the tablet will be left whole.

Hypothesis: Which do you think will react faster, a crushed tablet or a tablet which has not been crushed?

Procedure:

1. Obtain two effervescent tablets and two cups of water.
2. Crush one of the tablets.
3. Put the uncrushed tablet in a cup of water, and the crushed tablet in the other cup.
4. Observe the reaction and record your results in your notebook.

Conclusion:

1. Was your hypothesis correct?
2. Which reaction went faster?
3. Why do you think this occurred?
4. How do the tablets relate to the diagrams above? Which diagram above represents the crushed tablet and which represents the tablet that was left whole?

Investigate further:
How do you think stirring would affect the speed of the reaction and how does this affect the surface area available for reaction? If desired, repeat the experiment again leaving both tablets whole but stirring one glass for the duration of the reaction.

Name ______________________

Lab Assistant__________________________

Date ________________________

Title: Rates of Reaction

Hypothesis:____
____

Report your results (take a picture and attach it or draw a picture)

Conclusions

1. Was your hypothesis correct?

____

____

2. Which reaction went faster?

____

____

3. Why do you think this occurred?

____

____

4. How do the tablets relate to the diagrams above? Which diagram above represents the crushed tablet and which represents the tablet that was left whole?

____

____

5. How did stirring affect the rate of reaction?

____

____

Signs of a Chemical Reaction

A big part of chemistry is studying the way two different substances interact, called a reaction. Sometimes it is easy to tell when a chemical reaction is occurring. Other times it is more difficult. A chemical reaction is one in which the atoms or molecules of the substance are changed in some way, whereas a physical change may appear to change the substance in some way but the atoms and molecules making up the substance have not actually changed. For example, tearing a piece of paper is a physical change, but burning a piece of paper is a chemical change.

In this experiment, we are going to perform a simple chemical reaction in order to observe one of the most notable ways we can tell a chemical reaction in occurring, color change.

Hypothesis: What do you think will happen when a clear liquid chemical is added to one that has been colored with dyes?

Procedure:

1. Obtain a cup of water.
2. Add a few drops of food coloring and stir.
3. Slowly begin adding small amounts of bleach. Stir if desired. Record your observations.
4. After excess bleach has been added, add an additional drop or two of food coloring. Record your observations.

Conclusions:

1. Was your hypothesis correct?
2. What did you observe?
3. Why do you think this occurred?

The structure of dyes allows them to reflect light back to our eyes, producing the colors we see. Bleach reacts with the dyes, altering their structures in ways that no longer allow them to reflect the same color of light. When bleach is used to remove a stain, then, it is not actually removing the source of the stain, it is just removing the stain's ability to reflect the same light so we no longer can see the color of the stain. The stain is, for the most part, still present, we just cannot see it anymore.

Name ___________________________

Lab Assistant________________________________

Date _____________________________

Title: Signs of a Chemical Reaction

Hypothesis:____
____

Report your results (take a picture and attach it or draw a picture)

Conclusions

1. Was your hypothesis correct?

____
____

2. What did you observe?

____
____

3. Why do you think this occurred?

____
____

Types of Reactions

One of the most basic aspects of chemistry is the reactions that occur between substances. These reactions can be classified based on the structure of the products and reactants as well as the way the reactants are interacting.

This experiment will focus on replacement reactions, both single and double replacement.

Single replacement reactions occur when one piece of a reactant is replaced with a different piece:
$AX + Y \rightarrow AY + X$

Double replacement reactions occur when the reactants of a reaction switch individual pieces:
$AX + BY \rightarrow AY + BX$

A double replacement reaction often involves an exchange of ions. Ions are atoms or molecules that have a positive or negative charge. Positively charged ions are attracted to negatively charged ions, in the same way that opposite poles of a magnet are attracted to each other. In the equation above imagine that A and B are positive ions, called cations, and X and Y are negative ions, called anions. This exchange of ions is frequent in precipitation reactions and acid base reactions.

Acid base reactions often result in the formation of a salt and water. The salt formed by acid base reactions can be common table salt but the term refers to a more general category of compounds: ions bonded together by opposing charges. The form this reaction typically takes is:
$HA + BOH \rightarrow H_2O + BA$
Where A is the acid anion and B is the base cation. BA represents the salt product.

One example of this is:
$2HI + Mg(OH)_2 \rightarrow 2H_2O + MgI_2$
In this reaction, the cations and anions of each reactant are switched, a double replacement reaction. The products of this reaction are water and magnesium iodide. The magnesium iodide is the salt product in this reaction.

This experiment will demonstrate a double replacement, acid base reaction.

Procedure:

1. Obtain a bowl or glass and fill it with lemon juice.
2. Add an antacid tablet.

The lemon juice is an acid and the antacid tablet is a base, the two react to form neutral water. Antacid tablets are used to neutralize stomach acid in order to prevent heartburn.

Conclusions:

1. Can you think of other examples single replacement reactions?
2. Can you think of other examples double replacement reactions?

Name ______________________

Lab Assistant___________________________

Date ________________________

Title: Types of Reactions

Report your results (take a picture and attach it or draw a picture)

Conclusions

1. Can you think of other examples of single replacement reactions?

____

____

2. Can you think of other examples of double replacement reactions?

____

____

Investigate Further:

1. Research the acid in the lemon juice and the base in the antacid tablet and write an equation for the chemical reaction that is occurring in this experiment.

____

____

2. Based on your equation, what are the bubbles being formed in the reaction?

____

____

Acids and Bases

A molecule is considered acidic if it donates, or readily gives up, hydrogen ions, H^+. A molecule is considered basic if it donates OH^- ions or accepts the H^+ ions donated by an acid. Many of the things that surround us are acidic or basic to a certain degree. The level of acidity or basicity is determined by the concentration of H^+ ions produced in the solution. A solution which contains a high concentration H^+ ions is acid, one that contains a low concentration of H^+ ions is basic, and one that contains a concentration of H^+ ions that is roughly equal to the concentration of H^+ ions in pure water is neutral, meaning neither acidic nor basic.

This lab will estimate the pH of several household substances.

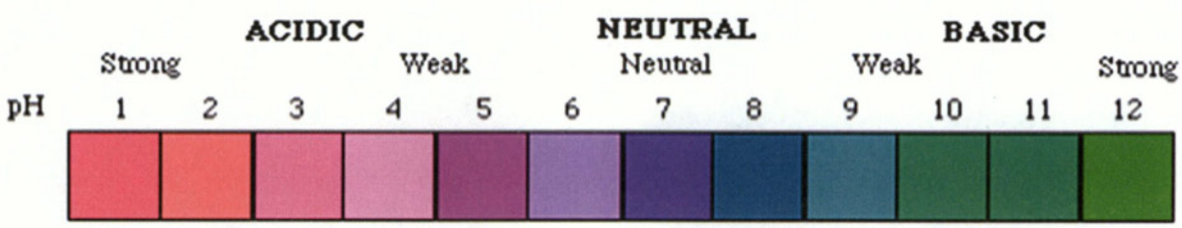
The first step of the experiment is to create an indicator solution that will demonstrate the pH of the solution. The pH of a solution is a measure of how acid the solution is. Solutions with a pH of 0-6.9 are acidic, with 0 being the most acidic and 6.9 being almost neutral. Solutions with a pH of 7 are neutral; pure water has a pH of 7. Solutions with a pH of 7.1-14 are basic, with 7.1 being almost neutral and 14 being the most basic.

An indicator will change color depending on the pH of the solution it is in. The indicator for this experiment will be made with red cabbage juice.

Indicator Preparation Procedure:

1. Cut a few red cabbage leaves into small pieces.
2. Boil the red cabbage leaves in a pot on the stove for several minutes, until the liquid is a dark purple, it may be necessary to add more leaves to the boiling water. Have your lab assistant help with using the stove and handling the boiling water.
3. Strain the leaves out of the juice.
4. The purple juice that remains is your indicator solution and should be put in a bottle and labeled.

For this particular indicator, an increasingly red color indicates the solution is acidic while an increasingly blue to green color indicates the solution is basic. There are many different kinds of indicators and each one will be different colors at different pH's.



Once the indicator solution has been prepared you can begin the experiment.

Procedure:

1. Obtain several clean cups. You will need one for each sample you wish to test and may test as many samples as you like.
2. Into each cup add a tablespoon or two of the desired liquid sample. Good samples include, but are not limited to, vinegar, lemon juice, milk, soda (clear works best so you can see the color change), baking soda dissolved in water, soap, glass cleaner containing ammonia, and others. Make sure your lab assistant helps you with handling these chemicals.
3. Into each cup of sample add just enough of the pH indicator solution to see a distinct color change.
4. Based on the colors you see estimate the pH of each sample. Record your results

Conclusions

1. Based on your results, which materials are examples of an acid?
2. What are a few examples of a base?
3. Were any of the solutions neutral or almost neutral? What were they?
4. Were you surprised by any of the results?

pH chart obtained from:
http://www.csun.edu/~jk323784/subjects/chemistry/labs/ph_value.pdf

Name ______________________

Lab Assistant__________________________

Date ________________________

Title: Acids and Bases

Report your results (take a picture and attach it or draw a picture)

Conclusions

1. Based on your results, what are a few examples of an acid?
____
____

2. What are a few examples of a base?
____
____

3. Were any of the solutions neutral or almost neutral? What were they?
____
____

4. Were you surprised by any of the results?
____
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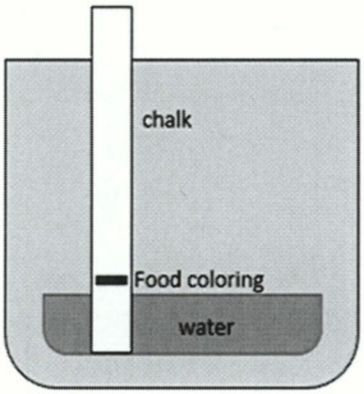
Chromatography

What is Chromatography? The word Chromatography comes from the Greek words for color writing. It refers to a method of separation by which something (often a liquid) is separated into the individual parts that make it. It was named this because in the development of this method the substance components were often many different colors (the scientist was looking at flower pigments).

In chromatography, a sample is placed at one end of a stationary, unmoving phase (often a piece of paper) and carried to the other end, usually by a liquid. As the sample is carried across the paper it is separated into the molecules that make up the sample as some components will stick to the paper and others will be carried with the liquid. This separation will be different for each substance because they have a different composition. It also depends on what liquid is used to carry the sample.
This experiment will focus on the way in which the sample is carried from one end of the test paper to the other end.



Procedure:

1. Obtain a long piece of white chalk and a drinking glass with roughly a centimeter of water in the bottom.
2. Put a drop or two of food coloring in a horizontal line on a piece of chalk slightly more than one centimeter above one end of the chalk.
3. Place the chalk in the glass, upright, so that only the end is in the water, make sure the water level is slightly below the line of food coloring.

   This experiment can be repeated with as many colors as desired.

As the water travels up the stick of chalk, it will carry the food coloring with it, however some of the food coloring will stick to the chalk as it travels. Chromatography takes advantage of this property.

In this experiment, the food coloring represents the sample which is being tested, the water is the solvent which carries the sample, and the chalk is the substance on which the sample moves, called the stationary phase.

Conclusions:

1. What did you observe?
2. Did any of the food colorings you tried separate into different colors?
3. Given the same amount of time to sit in the water did some parts of the food colorings move farther or faster than other parts?

Name ______________________

Lab Assistant__________________________

Date ________________________

Title: Chromatography

Report your results (take a picture and attach it or draw a picture)

Conclusions

1. What did you observe?

____

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2. Did any of the food colorings you tried separate into different colors?

____

____

3. Given the same amount of time to sit in the water did some parts of the food colorings move farther or faster than other parts?

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Crystal Formation

As a substance cools and turns from a liquid to a solid, or as it settles out of a solution, the molecules will often arrange themselves into a regular, repeating pattern that makes it easier for them to bunch together. Substances that form these patterns are said to be crystals, or have a crystalline structure.

Many of the chemicals in our homes have a crystal structure. This experiment will examine one of these chemicals and allow you to grow your own crystals.

One place in nature that we see crystal formation is in caves where water can form stalactites and stalagmites. You will use the same method to grow your crystals today.

Materials: one large cup or bowl, two identical sized cups, a small plate or bowl, water, baking soda, yarn.

You will first need to make a saturated solution of baking soda. Saturated means it is so concentrated that no more will dissolve in it. The substance which is dissolving in the liquid is called solute and the liquid it is being dissolved in is called solvent. A saturated solution, then, is one which is not capable of holding any more solute than it already has. For faster growth you can create a supersaturated solution, which is one that has more solute than it would normally hold. Make this initial solution in the larger bowl or cup so that you will have enough to nearly fill the smaller two cups.

To create the saturated solution, simply add enough baking soda to the water so that no more will dissolve. You will see some of the baking soda settle to the bottom and it will not dissolve no matter how much you stir the solution.

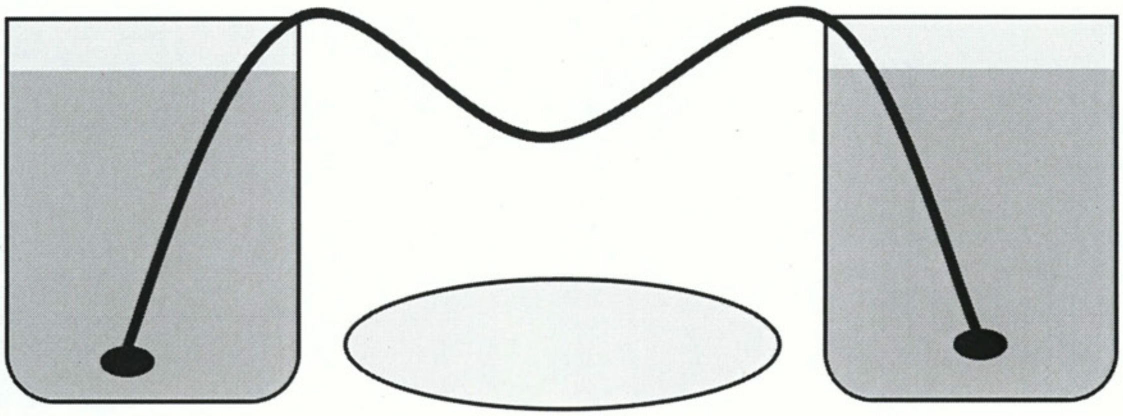
To create a supersaturated solution, you will need to heat the water on the stove or in the microwave because warm solvents are capable of holding more solute than cooler ones. Have your lab assistant help you with this. You will then make a saturated solution with the heated water. As the water slowly cools, without being disturbed, it will become supersaturated because it has the amount of solute that the heated solution contained, but has now cooled.

Once you have made your solution pour it slowly into the other two cups, they should have roughly equal amounts of solution in them. If you are using a supersaturated solution you may pour it into the cups while it is still warm. Make sure that none of the undissolved (solid) baking is transferred into the cups, especially if you are using a supersaturated solution.

Experiment setup:

1. Set this experiment up somewhere where you can leave it for a few days without it being disturbed.
2. Place the two cups with solution in them a small distance apart, just enough for you to put the smaller plate or bowl between them.
3. Cut a length of string long enough to stretch between the two cups and have a dip in the middle, as shown below.

4. Tie the paperclips or some other weight (such as a metal bolt or washer) to the two ends of the string.
5. Put one end in each cup.
6. Make sure the string is long enough that the string is not tight between the two cups, it should bend enough in the middle that it is slightly below the line of solution. You can move the cups closer together or farther apart to adjust this.



7. You will now need to let the setup sit for a few days. You should see some crystal growth on the string itself and, eventually, on the plate as the solution drips onto it. It may be necessary to add more solution after a few days just make sure that it is either saturated or supersaturated otherwise the crystals you already have will begin to dissolve.

The crystals that grow on the string are stalactites and the ones on the plate are stalagmites. You can remember the difference because stalactites cling tight to the ceiling (both have C's) whereas stalagmites grow mighty on the ground (both have G's).

Conclusions:

1. Did you have crystals growing on the string? On the plate?
2. Closely examine the crystals, using a magnifying glass if available. Can you see the pattern in the shape of the crystals?

Name ________________________

Lab Assistant____________________________

Date __________________________

Title: Crystal Formation

Report your results (take a picture and attach it or draw a picture)

Conclusions

1. Did you have crystals growing on the string?

____

____

2. Closely examine the crystals, using a magnifying glass if available. Can you see the pattern in the shape of the crystals?

____

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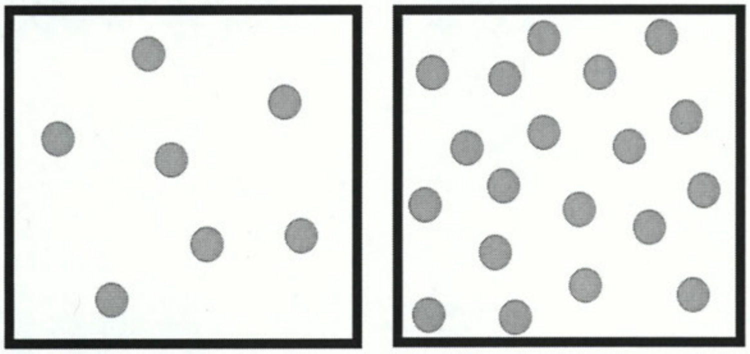
Density

Density is a measure of the amount of mass that occupies a given volume. Materials which are denser will feel heavier than less dense objects of the same size. The pictures below demonstrate the idea of density. The boxes are the same size yet they have a different number of molecules inside them. The molecules in the box on the right are packed more tightly together. This material, therefore, is denser than the material represented by the left box. Think of a block of wood and a block of metal that are the same size, the metal will weigh more because it is denser.



This experiment will demonstrate that equal volumes do not always have equal masses.

Hypothesis: What do you think will happen if two liquids of different density are mixed? The liquids you will be using will remain separated in a way that will allow you to view the individual layers. Knowing that one liquid is less dense than the other, what do you think will happen when the two are placed in the same container?

Procedure:

1. Obtain a container that can be sealed, such as a glass jar with a screw on lid or a bottle with a cap.
2. Obtain equal amounts of vegetable oil and water, enough of each to fill the container with equal amounts of oil and water.
3. Place the water and the oil in the container together.
4. Add a drop or two of food coloring; this will make it easier to see the layers.
5. Allow the container to sit for a minute or two to allow the layers to separate.

Conclusions:

1. Was your hypothesis correct?
2. What do you notice about the two liquids? Record your observations.
3. Try shaking the container vigorously then allow it to sit for a few minutes. What happens?
4. Based on the results of the experiment, which liquid do you think is less dense? Explain.

Name ________________________

Lab Assistant ____________________________

Date __________________________

Title: Density

Hypothesis: ____
____

Report your results (take a picture and attach it or draw a picture)

Conclusions

1. Was your hypothesis correct?

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2. What do you notice about the two liquids?

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3. Try shaking the container vigorously then allow it to sit for a few minutes. What happens?

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4. Based on the results of the experiment, which liquid do you think is less dense? Explain.

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Heat

Temperature is simply a measure of heat, but what then, is heat? What makes something feel hot or cold? Heat is a measure of the kinetic energy (energy of motion) of a molecule. The more energy the molecule has in its movement, the warmer it will feel to the touch.
Molecules are constantly in motion and it is this motion which gives the feeling of heat. The molecules in something that feels cold are simply moving slower. The feeling of heat comes from the molecules of the object you are touching running into your hand. If the molecules of the object are moving faster than the molecules in your hand, it feels hot because the molecules in the object transfer some of their energy to your hand. If the molecules of the object are moving slower than the molecules in your hand, it feels cold because the molecules in the object absorb some of the energy from your hand.
To demonstrate the motion of the molecules, which are far smaller than we can see, we need only water and food coloring.

Procedure:
1. Obtain two bowls of water, heat one to very hot, near boiling in the microwave or over the stove (ask your lab assistant to help you with this part) and cool the other in the refrigerator or freezer. The bowls of water should not be boiling or frozen but should be drastically different in temperature. It may also be helpful to use a white or clear bowl on a white surface so you can more easily see the food coloring.
2. Add one drop of food coloring to each bowl and watch what happens.

Hypothesis: What do you think will happen in each bowl of water? Do you think the food coloring will spread through the water at the same rate in each of the bowls?

Conclusion:
1. Was your hypothesis correct?
2. What happened to the food coloring in each bowl?
3. Why do you think it moved at different speeds and how does this relate to the temperature and kinetic energy of the water molecules?
4. Are there other things in nature that also move slow when it is cold; such as animals that hibernate?

Name ________________________

Lab Assistant_____________________________

Date __________________________

Title: Heat

Hypothesis:____
____

Report your results (take a picture and attach it or draw a picture)

Conclusions

1. Was your hypothesis correct?

____
____

2. What happened to the food coloring in each bowl?

____
____

3. Why do you think it moved at different speeds and how does this relate to the temperature and kinetic energy of the water molecules?

____
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4. Are there other things in nature that also move slow when it is cold; such as animals that hibernate?

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Pressure, Volume, and Temperature

Pressure can be described as the force a system exerts on another system. Volume is the amount of 3-D space a system occupies. Temperature is a measure of the heat of a system. All three of these concepts are related to and dependent upon each other. Changing one of these factors will affect one or both of the other two factors. When making a change to the system the effect can be calculated using the formula:

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

This experiment will be performed at a constant temperature meaning that T_1 is equal to T_2 so they will cancel out and the equation that is left is $P_1V_1=P_2V_2$. The two terms in equation are indirectly related, meaning that increasing one will force the other to be decreased so that that the overall product remains constant. Use the following math problem as an example: 2*6=3*4. The equation is true but the values are different; increasing one causes the other to decrease proportionally.

Procedure:

1. Obtain a few ketchup packets, a glass of water and a plastic bottle with cap (such as a two-liter soda bottle or a water bottle.
2. Test the ketchup packets one at a time by placing them in the glass of water until you find one that neither sinks nor floats at the top, but floats in roughly the middle of the glass.
3. Place this ketchup packet in the bottle and completely fill the bottle with water.
4. Secure the cap on the bottle.
5. Squeeze the bottle and observe the motion of the ketchup packet.

Hypothesis: What do you think will happen as you squeeze the bottle?

Conclusions:

1. Was your hypothesis correct?
2. How did squeezing the bottle affect the pressure and volume inside the bottle?
3. Why do you think changing these two factors caused the motion of the ketchup packet which you observed? (Think about this question in terms of the effect on the density of the system.)

Name ______________________

Lab Assistant__________________________

Date ________________________

Title: Pressure, Volume, and Temperature

Hypothesis:____
____

Report your results (take a picture and attach it or draw a picture)

Conclusions

1. Was your hypothesis correct?

____
____

2. How did squeezing the bottle affect the pressure and volume inside the bottle?

____
____

3. Why do you think changing these two factors caused the motion of the ketchup packet which you observed? (Think about this question in terms of the effect on the density of the system.)

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Name ______________________

Lab Assistant__________________________

Date ________________________

Independent Study title ______________________________________

Hypothesis____
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Materials____
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Procedure

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Data

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Analysis and Conclusions

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Name ____________________

Lab Assistant ________________________

Date ______________________

Independent Study title ___________________________________

Hypothesis ____
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Materials ____
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Procedure

Data

Analysis and Conclusions

Name ____________________

Lab Assistant________________________

Date ______________________

Independent Study title ____________________________________

Hypothesis____

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Data

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Analysis and Conclusions

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Chemistry at Home

Level 2

IMPORTANT

Note to the Project Helpers

As the project helper for this project you will be the lab assistant. You will be responsible for supervising tasks that may not be suitable for children to perform totally on their own (such as using a stove). None of the experiments in this book are inherently dangerous but if instructions are not followed properly, they may become dangerous. That being said, make sure to use your best judgement when dealing with chemicals. For example, if a chemical has a strong or noxious odor move the experiment outside or to a well-ventilated area. The chemical products of the experiments will also be safe enough that they will not require special disposal. All chemicals can be poured down the drain and flushed with running water.

When using chemicals, make sure to follow all safety procedures provided by the manufacturers. Some chemicals may be slightly different in composition based on brand so be sure to follow the instructions they provide as all of these differences cannot be accounted for in the design of the experiments.

Safety equipment, especially eye protection, is recommended for all experiments involving chemicals. Some chemicals used may also be irritating to the skin. If contact with any chemicals occurs, follow the manufacturer's instructions for cleaning the area. Typically flushing the area with cold water will be sufficient. Some chemicals may also stain clothes, so a lab coat may also be desired. Alternatively, the students may wish to wear old clothes when performing some of the experiments. It is best to avoid direct contact with the chemicals unless you know it is safe to have contact with them.

The chemicals required for these activities can all be found at a typical grocery store or pharmacy. You should never need to purchase high grade, expensive, or toxic chemicals for the experiments. Some experiments require equipment such as a thermometer, scale, and stopwatch.

Note to the 4H member

This project will demonstrate a few basic chemistry topics. Each level will cover the same topics in greater detail as you progress.

The activities are divided into sections based on the topics and purpose of the activities. The Introduction section is purely informational and will be useful in furthering your understanding of chemistry itself. The Describing Reactions section examines the reaction process specifically, rather than a chemistry topic. Chemical reactions are the basis of chemistry and therefore it is important to understand what is occurring when chemicals react. The final section is the Experiments section. These are what one typically thinks of when imagining a chemistry experiment.

Each year you will need to complete one activity from the "Introduction" section, one activity from the "Describing Reactions" section, and two activities from the "Experiments" section. You also need to complete one independent activity, this can be something such as an interview of a scientist, an additional experiment that you have found and want to try, a brief research paper, or some other scientific activity.

Topics for the final display project can be any of the activities from the "Describing Reactions" or "Experiments" sections, or from one of the independent study activities you choose to perform. The project display should be a formal report of the experiment and your data. A formal report typically includes each step of the scientific method: the question to be answered (objective of the experiment), research (basic information on the topic, an introduction to the concept), a hypothesis, an outline of the experiment (the procedure followed), an analysis of the data including charts and graphs, and a conclusion (was the hypothesis correct and what you learned from this experiment).

LAB NOTEBOOK
From a scientific standpoint, it is important to always record the results of any scientific inquiry. This insures that others who look at your data will be able to understand the experiment and learn from your data which helps science, as a whole, move forward.

For this level, the lab notebook has been provided in the form of pages with room to fill out the questions. Feel free to fill out a more thorough lab notebook if you wish. When filling out your lab report, be sure to use complete sentences. When forming a hypothesis remember that there are no wrong answers to this question. A hypothesis is simply a guess based on prior knowledge. If your guess is wrong do not be upset, use this as an opportunity to learn and try the experiment again.

Name ______________________________

Project Helper (Lab Assistant) ______________________________

Goals for this Project:

1. ______________________________
2. ______________________________
3. ______________________________

Did you achieve these goals? How?

1. ______________________________
2. ______________________________
3. ______________________________

Activity	Date completed	Project Helper Initials	Independent Activities
Introduction			Description:
Scientific Method			
Periodic Table			
Vocabulary			
Describing Reactions			Date: Helper Initials:
Signs of a Reaction			Description:
Types of Reactions			
Rates of Reactions			
Experiments			
Acids and Bases			Date: Helper Initials:
Chromatography			Description:
Crystal Formation			
Density			
Pressure, Volume, & Temperature			
Temperature			Date: Helper Initials:

Each year complete:

- 1 activity from the "Introduction" section
- 1 activity from the "Describing Reactions" section
- 2 activities from the "Experiments" section

You also need to complete 1 independent activity each year. This can be an interview of a scientist, an additional experiment that you have found and want to try, a brief research paper, or some other scientific activity. Additional notebook pages for these independent study activities have been included at the back of the book.

The Periodic Table

The Periodic Table of elements is an arrangement of the elements that orders them based on atomic number and groups them based on properties.

Atoms are made up of three major pieces: protons, neutrons, and electrons. Protons are positively charged particles, neutrons are uncharged particles, and electrons are negatively charged particles. The number of protons an atom has determines which element it is and is called its atomic number. For an uncharged atom, the number of electrons will be equal to the number of protons. The number of neutrons varies but is typically close to the number of protons. Atoms with the same number of protons but different number of neutrons are isotopes of the same element.

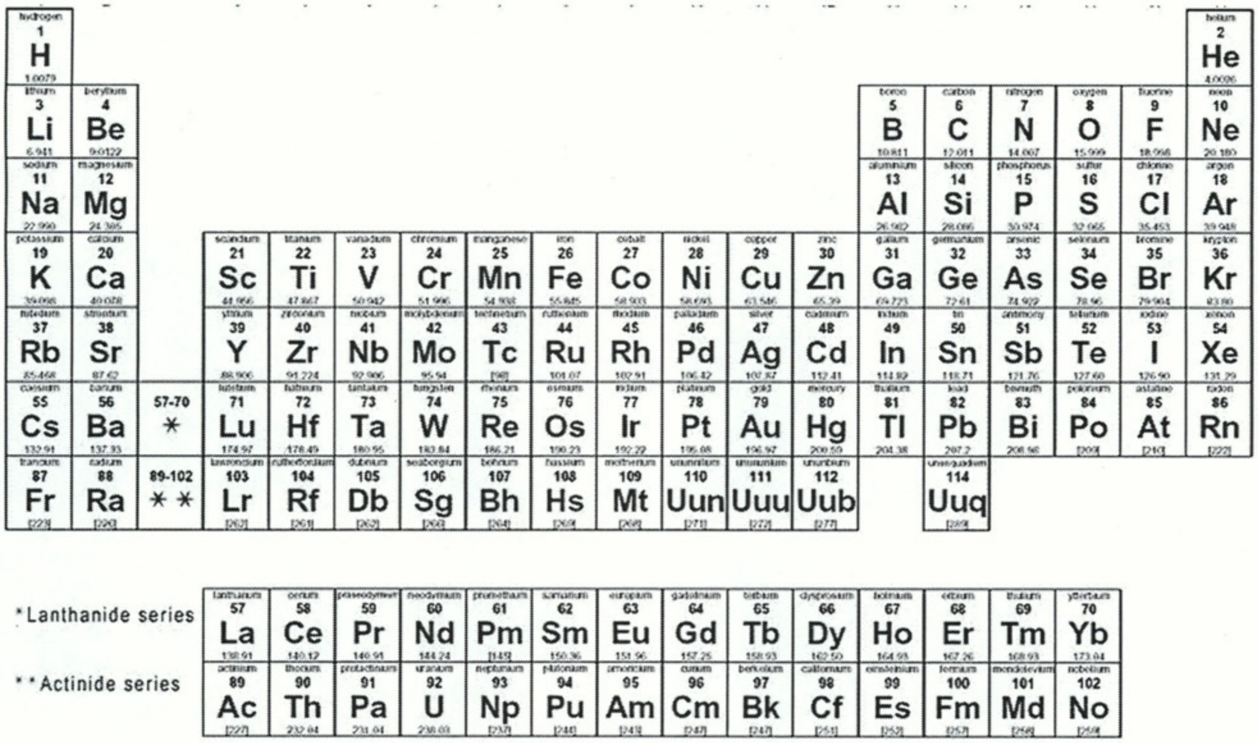
Atoms make up all matter. Every substance is just a rearrangement of the elements on the periodic table. This activity will give you the opportunity to learn more about the periodic table.

The elements in the periodic table are grouped based on shared properties. A column in the periodic table is called a group or a family. The main groups are the two and last two columns.

The first column is called the alkali metals, they are highly reactive when placed in water. Look for videos on the internet of the alkali metals being mixed with water but do not attempt this yourself as the reaction can be quite explosive. These elements typically have a +1 charge.
The second column is the alkaline earth metals. These elements are also reactive with water, though the reaction is typically less violent. These elements frequently have a +2 charge.
The second to last column is the halogen group. These elements often react with elements from one of the first two columns because the halogen elements typically have a -1 charge, which is attracted to the positively charged elements.
The last column is the noble gases group. The elements in this group are typically unreactive and almost always have a neutral charge. Additionally, these are the elements typically used in what we call neon lights, though only the red lights are made from neon, the other colors come from the other elements in this group.

The order and arrangement of the periodic table also lead to trends in the properties of the elements, depending on the location of the element on the periodic table.
Moving down and left, the elements progressively become better at losing electrons. This is measured by the energy of ionization, the amount of energy an atom releases when it loses an electron. A lower ionization energy means the loss of electrons is more favorable, or more likely to occur.
Moving up and right (and excluding the noble gases column), the elements become progressively better at attracting electrons. This property is called electron affinity or electronegativity. A higher electronegativity means the element has a greater attraction to electrons.
Moving down and left, the size of the elements gradually increases.

Based on the above information, answer the following questions:



1. What is the most common charge carried by an ion of Sodium (Na)?
2. What is the most common charge carried by an ion of Calcium (Ca)?
3. What is the most common charge carried by an ion of Oxygen (O)?
4. most common charge carried by an ion of Iodine (I)?
5. Which element is larger? F or Cl
6. Which element is larger? S or Cl
7. Which element has a greater electronegativity? F or Cl
8. Which element has a greater electronegativity? S or Cl
9. Which element has a greater ionization energy? Rb or Cs
10. Which element has a greater ionization energy? Cs or Ba
11. Which element will be more reactive in water? K or Kr

Scientific Method

The scientific method can help anyone discover more about nearly any topic. The usual steps provide a structure that leave little doubt as to how to proceed but which are flexible enough to accommodate a wide variety of subjects.

On the following page is the scientific method, with an explanation of each of the steps, read the steps and then answer the following questions.

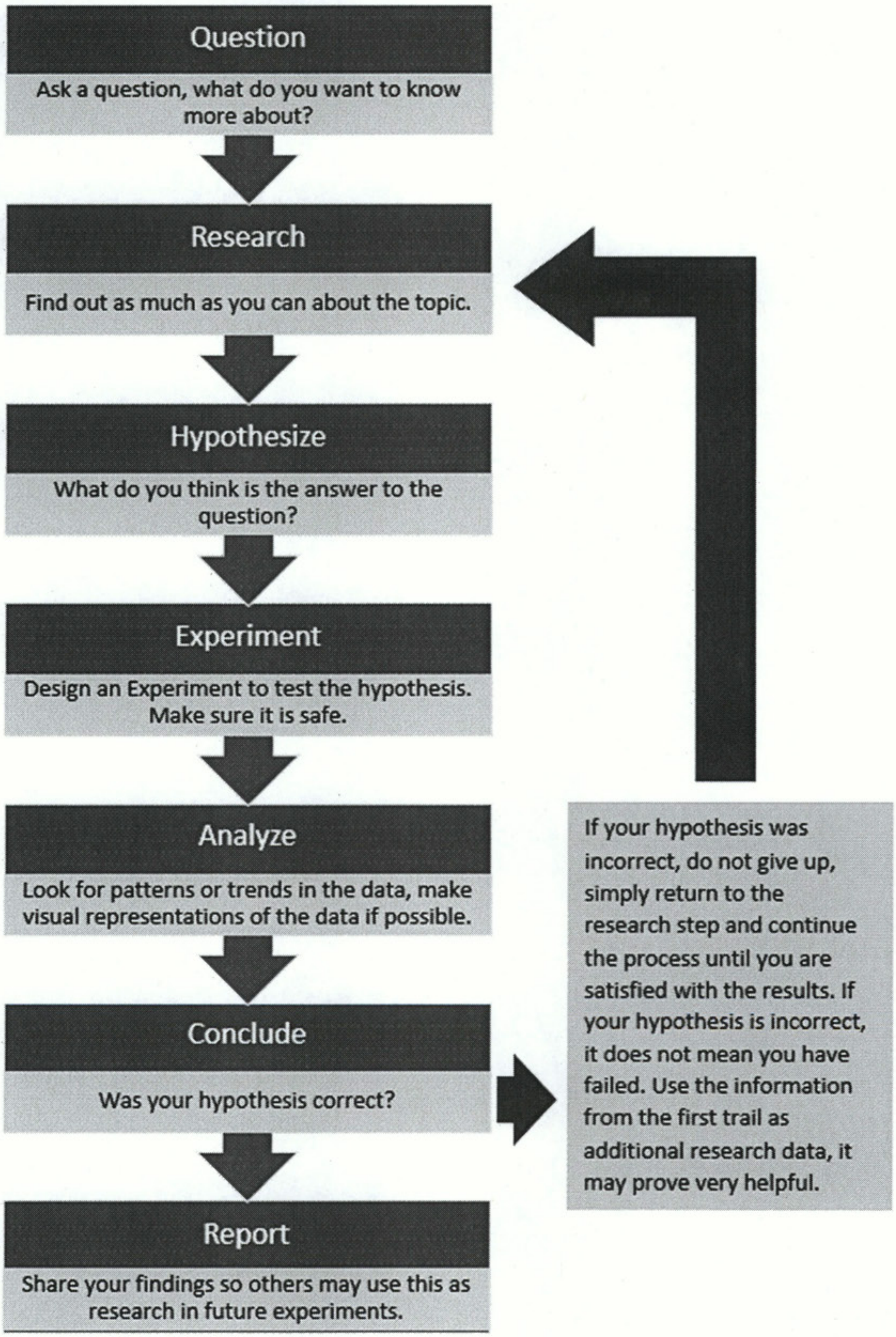
1. Do you think there should be any additional steps? Has anything important been left out?
2. Do any steps seem more important than others? Please explain.
3. Do you see how this process could be applied to other subjects, a difficult math problem, a confusing literary work, etc.?
4. Which step or steps do you think will be the most challenging and why? How can you overcome these obstacles?
5. How does sharing information with others, reporting your results, help science advance and make new discoveries?

Practice thinking analytically and critically by practicing a few of steps of the scientific method.

1. Choose a topic which interests you. To begin with, it may be helpful to choose something which has already been extensively studied.
2. What do you want to know about this topic? Research the topic and compile the data in tables, charts, or another appropriate format.
3. Analyze the information you have gathered. Is there enough here for you to draw a conclusion of your own?
4. What is your conclusion on the subject? Do you agree or disagree with what others believe? Support your statement.
5. Share your thoughts with others and ask them for their thoughts. This will help spread information.

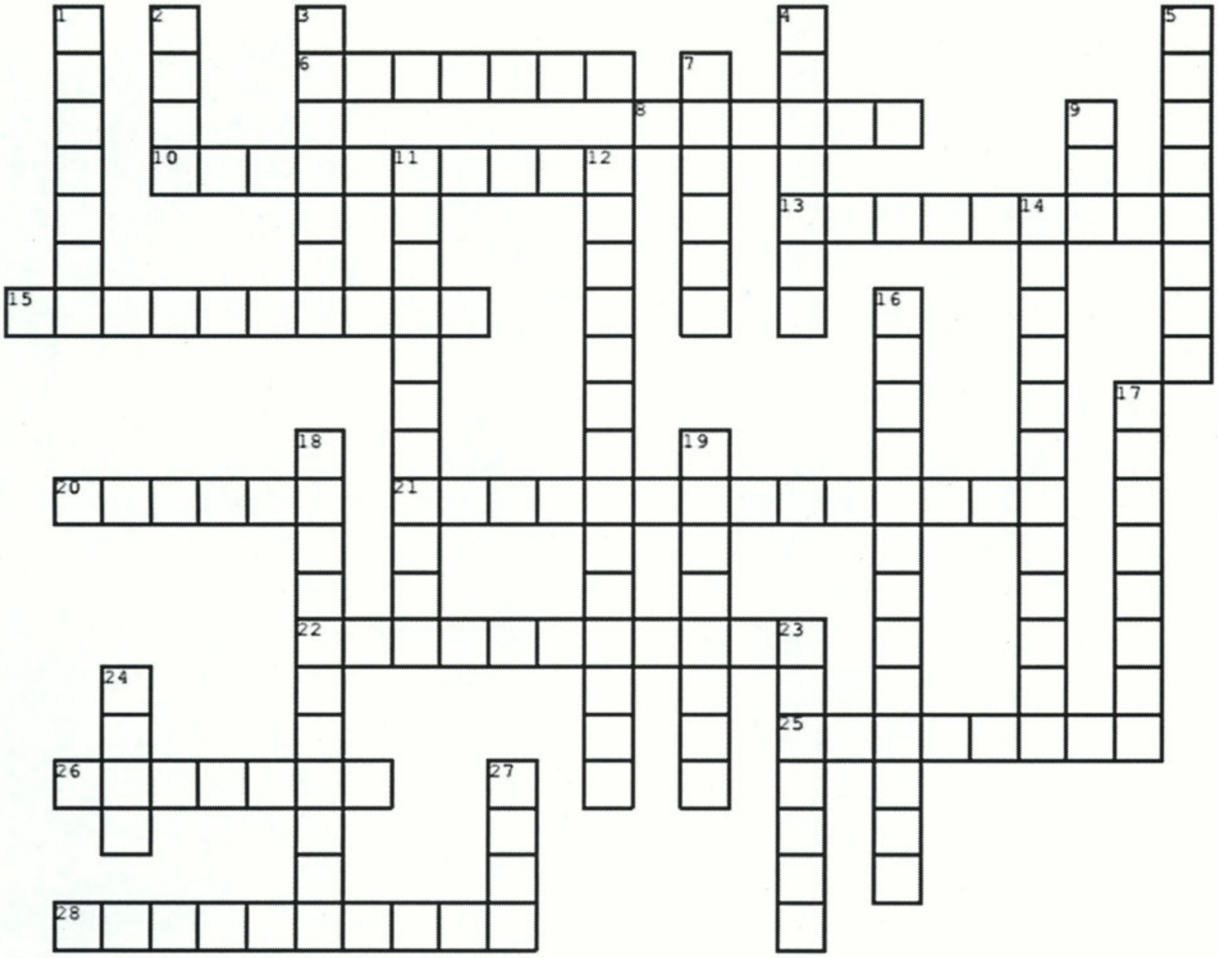
If you are having trouble choosing a topic, think about things which have been studied and for which there are statistics you can analyze, but are still not fully understood or agreed upon by professionals. This will allow you to research a topic and form your own, informed opinion. Such topics include:

- Is climate change a man-made situation, and is it a problem we should be worried about?
- Have video games led to an increase in teen violence?
- Is music or white noise beneficial or detrimental to student study habits?
- Are uniforms beneficial to the classroom learning environment?
- Any other topic you feel strongly about.


Question
Ask a question, what do you want to know more about?
Research
Find out as much as you can about the topic.
Hypothesize
What do you think is the answer to the question?
Experiment
Design an Experiment to test the hypothesis. Make sure it is safe.
Analyze
Look for patterns or trends in the data, make visual representations of the data if possible.
Conclude
Was your hypothesis correct?
Report
Share your findings so others may use this as research in future experiments.
If your hypothesis was incorrect, do not give up, simply return to the research step and continue the process until you are satisfied with the results. If your hypothesis is incorrect, it does not mean you have failed. Use the information from the first trail as additional research data, it may prove very helpful.

Vocabulary

Complete the crossword below



Created with TheTeachersCorner.net Crossword Puzzle Generator

Across

6. in a solution the substance which is doing the dissolving, the substance which is present in a greater amount

8. in a solution the substance which is being dissolved, the substance which is present in a lesser amount

10. a reaction for which the products are at a lower energy that the reactants, a reaction which has an overall release of energy

13. the starting substances of a chemical reaction

15. theory based on background knowledge but which has not yet been tested or proven

20. positively charged particles in the nucleus of atoms

21. speed at which a reaction occurs, speed at which reactants are consumed or products are produced

22. a measure of heat. SI unit is Kelvin (kelvin units are equal to celsius + 273)

25. negatively charged particles which surround the nucleus of atoms

26. a combination of two or more substances with all pieces being visible; example sand in water

28. the mass of an atom, approximately equal to sum of the number of protons and neutrons

Down

1. equal to mass of mass divided volume, the amount of mass that occupies a space

2. a substance which accepts H+ ions, releases OH- ions, or donates electrons when in aqueous solution

3. atoms of an element that have different number of neutrons

4. neutral particles in the nucleus of atoms

5. the force exerted on an object by another object with which it is in contact. SI unit is Pascals

7. the amount of 3-Dimensional space something occupies. SI unit is cubic meters

9. an atom that has lost or gained an electron and therefore carries a charge

11. a reaction state in which the rate of product production is equal to the rate of the reverse reaction

12. a method of separating a substance into its components by passing it through a medium

14. the number of protons in an atom

16. the energy of motion

17. a combination of two or more substances with the appearance of being only a single substance, no reaction is occurring

18. a reaction for which the products are at a higher energy than the reactants, a reaction which must absorb energy overall

19. the ending or produced substances of a chemical reaction

23. a substance which cannot be chemically converted or broken down to another substance

24. a substance which releases H+ ions or accepts electrons when in aqueous solution

27. the amount of matter that makes up an object or substance. Si unit is grams

Rates of Reactions

Some chemical reactions occur very quickly, such as the reaction between vinegar and baking soda. Others take much longer, such as the rusting of a nail. Many things affect the speed of a reaction. Some of the biggest factors in reaction speed are temperature, surface area available for the reaction to occur, and the concentration of the chemicals being used.
This reaction will examine the relationship between temperature and reaction rate. Temperature is a measure of kinetic energy, the energy of motion. For a reaction to occur the chemicals which are interacting must do so with enough force to successfully react. If the molecules of the substances do not interact with sufficient energy, no reaction will occur. This energy is called activation energy. This experiment will focus on raising the energy of the molecules, in order to increase the reaction speed. A general rule of thumb is that for every increase of 10°C (approximately 18°F) the reaction rate doubles.

Hypothesis: Which reaction do you think will be completed first, a hot reaction or a cold one? How does this relate to the rate of reaction?

Procedure:

1. Obtain two or more glasses of water and the same number of effervescent tablets, a thermometer (preferably one that measures °C) and a stopwatch.
2. Heat one of the cups of water in a microwave or over the stove and chill the other in the refrigerator. The cups should not be boiling or frozen but should be drastically different in temperature. This experiment can be repeated as many times as desired with multiple temperatures of water. Be sure to record all data collected.
3. Record the temperature of each cup of water before placing the tablets in the water.
4. Place one tablet in a cup and start the stopwatch.
5. Stop timing the reaction when it becomes apparent that a reaction is no longer occurring.
6. Repeat for each cup of water at the desired temperatures.
7. Record the length of the reaction for each temperature, in a table similar to the one below.

Temperature:					
Time:					

Conclusion:

1. Was your hypothesis correct.
2. Which reaction proceeded faster?
3. Why do you think this is?
4. What is the reaction that is occurring? How can you tell?

Name ______________________

Lab Assistant__________________________

Date ________________________

Experiment title ______________________________________

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Signs of a Chemical Reaction

A big part of chemistry is studying the way two different substances interact, called a reaction. Sometimes it is easy to tell when a chemical reaction is occurring, other times it is more difficult. A chemical reaction is one in which the molecules of the substance are changed in some way, whereas a physical change may appear to change the substance in some way but the molecules making up the substance are still the same. For example, tearing a piece of paper is a physical change, but burning a piece of paper is a chemical change.

In this experiment, you are going to perform a simple chemical reaction so you can observe one of the most notable ways to tell a chemical reaction has occurred: a change in temperature. This experiment will consist of two separate reactions which may look similar, but are chemically different.

Procedure:

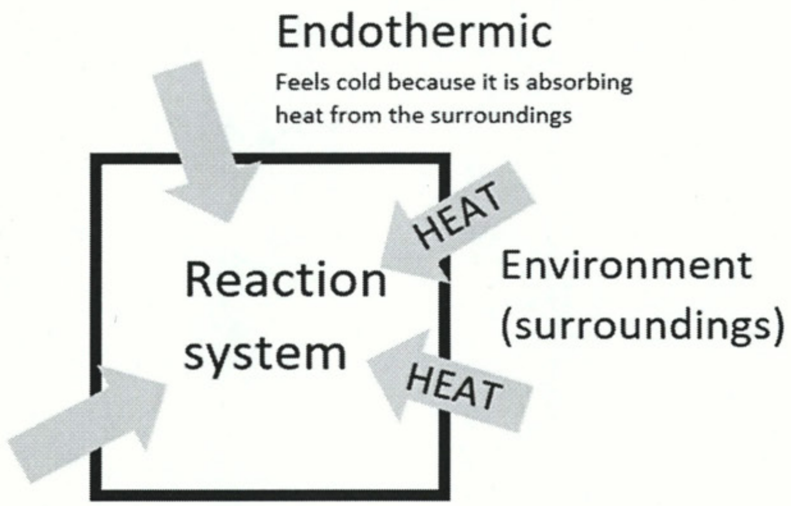
1. Obtain a baking pan and a trash bag (for easy clean up), two large bottles (such as two-liter soda bottles), vinegar, baking soda, liquid dish soap, active yeast, and hydrogen peroxide.
2. Into one bottle, place one to two cups of vinegar. In the other bottle, put an equal amount of hydrogen peroxide and a small squirt of dish soap.
3. Make sure you record exact amounts of each chemical used and label the bottles so you know which chemicals are in each. Be aware that the greater amount of chemical used, the larger the reaction will be. For these reactions, that can mean a much larger mess. The reactions are not dangerous, they will simply create large amounts of foam, which may then require a great deal of clean-up time.
4. Lay the trash bag over the baking pan and then place the bottle on the trash bag.
5. Into the bottle containing the vinegar, add baking soda. As the reaction proceeds, carefully feel the bottle. What do you observe?
6. Into the bottle containing hydrogen peroxide and dish soap, add the active yeast. Again, as the reaction proceeds, very carefully feel the bottle. What do you notice about this reaction?

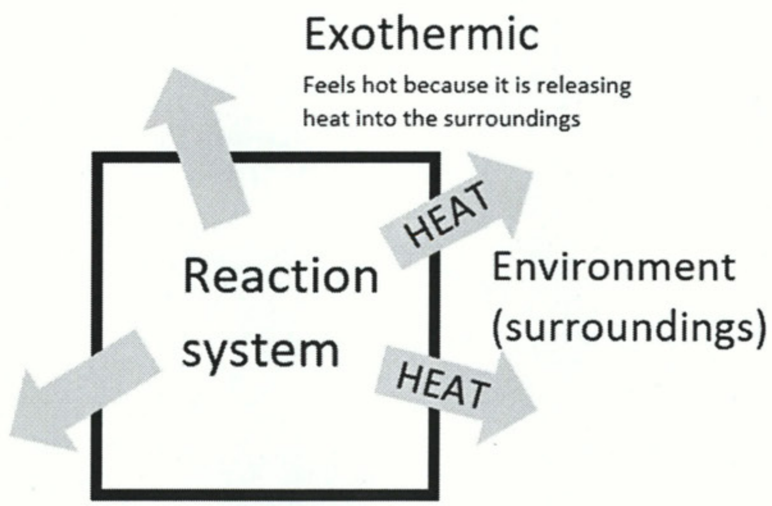
Conclusions:

1. How did the temperature change for the vinegar and baking reaction?
2. How did the temperature change for the hydrogen peroxide and yeast reaction?

These changes in temperature indicate a chemical reaction has occurred because the temperature change is a direct result of only the chemicals reacting and not because of an outside force. Water boiling, for example, is a physical change because the increase in temperature is a result of applied heat, not a reaction the water is undergoing. You likely observed that the vinegar and baking soda reaction felt cold to the touch and the hydrogen peroxide and yeast reaction felt warm. These reactions are classified as endothermic and exothermic.

Endothermic means heat is entering the reaction from outside the system. The absorbed heat will be used to power the reaction. The system feels cold to you because the heat entering the system from the surroundings is being converted to different forms of energy in the products of the reaction. Exothermic means heat is being produced by the reaction and is exiting to the surroundings. The formation of the products results in a release of heat energy. The system feels warm because the heat is released from the system, into the surroundings.





Name ______________________

Lab Assistant__________________________

Date _______________________

Experiment title ______________________________________

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Attach Additional Data (tables, graphs, and images) on separate page

Types of Reactions

One of the most basic aspects of chemistry is the reactions that occur between substances. These reactions can be classified based on the structure of the products and reactants as well as the way the reactants are interacting.

This experiment will focus on two types of reactions: decomposition, and its reverse, synthesis.

A decomposition reaction occurs when a single reactant breaks apart into two or more pieces:
$AB \rightarrow A + B$

A synthesis reaction is the reverse of a decomposition reaction. In a synthesis reaction two pieces combine to form a single product:
$A + B \rightarrow AB$

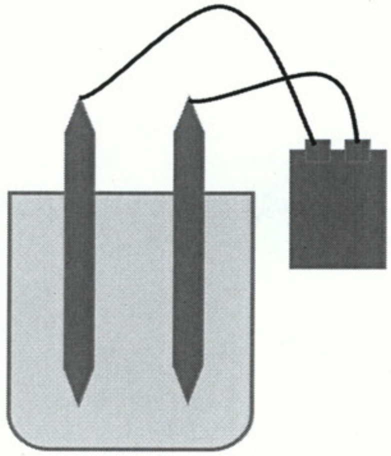
In each of these reactions you will notice that the reaction started and ended with the same number of each piece. This is because matter cannot be created or destroyed, only transformed. Chemical reactions do not create or destroy material, only change it in some way.

One example of this transformation, and a synthesis reaction, is the reaction that forms common table salt: $2Na + Cl_2 \rightarrow 2NaCl$. The element Na is Sodium; it is explosive when placed in water, and Cl_2 is a poisonous gas. However, when the two react together they form an edible compound, NaCl, sodium chloride. The reaction conserves the total amount of overall matter but drastically changes the properties of the matter involved.

The reaction you will be performing in this experiment will be a decomposition, breaking water into its components.

Procedure:

1. Obtain a cup of water, two pencils, a 9-volt battery, and two small wires with alligator clips.
2. Sharpen both ends of the pencil, exposing the graphite on both ends.
3. Put the pencils in the cup of water making sure that the cup is not so full that the pencils are fully submerged. Make sure the ends of the pencils are not touching.
4. Connect each wire so that one end is on a battery terminal and the other is on the exposed end of one of the pencils.
5. Watch the setup closely, you should be able to see small bubbles forming on the ends of the pencils.



The bubbles that are forming are Hydrogen and Oxygen gas, H_2 and O_2. These gases are flammable so be careful with the entire setup.

The battery is used to supply energy to the water. Energy is necessary to break the bonds in the water because water will not break down on its own. This reaction requires energy input to help the reaction start. This is called activation energy. In this experiment the battery provides the necessary energy input to allow the reaction to proceed.

Conclusions:
1. The unbalanced equation for this reaction is $H_2O \rightarrow H_2 + O_2$. Balance the equation so that there are the same number of each atom on both sides of the equation. (Do not change the subscript numbers, add additional numbers of the given molecules.)
2. Can you think of any other examples of decomposition or synthesis? These don't have to be chemical reactions, you can use any example where pieces are put together in an exact proportion, such as recipe for cookies or pieces of a model kit.

Decomposition: http://www.shmoop.com/chemical-reactions/decomposition.html

Name ______________________

Lab Assistant __________________________

Date ________________________

Experiment title ______________________________________

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Acids and Bases

A molecule is considered acidic if it donates, or readily gives up, hydrogen ions, H^+. A molecule is considered basic if it donates OH^- ions or accepts the H^+ ions donated by an acid. Many of the things that surround us are acidic or basic to a certain degree. The level of acidity or basicity is determined by the concentration of H^+ ions in the solution. A solution which contains a high concentration H^+ ions is acid, one that contains a low concentration of H^+ ions is basic, and one that contains a concentration of H^+ ions that is roughly equal to the concentration of H^+ ions in pure water is neutral, meaning neither acidic nor basic.

This lab will demonstrate the effects of mixing an acid and a base.

Hypothesis: What do you think will happen when an acid and a base are mixed together?

The first step of the experiment is to create an indicator solution that will demonstrate the pH of the solution. The pH of a solution is a measure of how acid the solution is. Solutions with a pH of 0-6.9 are acidic, with 0 being the most acidic and 6.9 being almost neutral. Solutions with a pH of 7 are neutral; pure water has a pH of 7. Solutions with a pH of 7.1-14 are basic, with 7.1 being almost neutral and 14 being the most basic.

An indicator will change color depending on the pH of the solution it is in. The indicator for this experiment will be made with red cabbage juice.

Indicator Preparation Procedure:

1. Cut a few red cabbage leaves into small pieces.
2. Boil the red cabbage leaves in a pot on the stove for several minutes, until the liquid is a dark purple. Have your lab assistant help with using the stove and handling the boiling water.
3. Strain the leaves out of the juice.
4. The purple juice that remains is your indicator solution and should be put in a bottle and labeled.

For this particular indicator, an increasingly red color indicates the solution is acidic while an increasingly blue to green color indicates the solution is basic. There are many different kinds of indicators and each one will be different colors at different pH's.

Once the indicator solution has been prepared, you can begin the experiment.

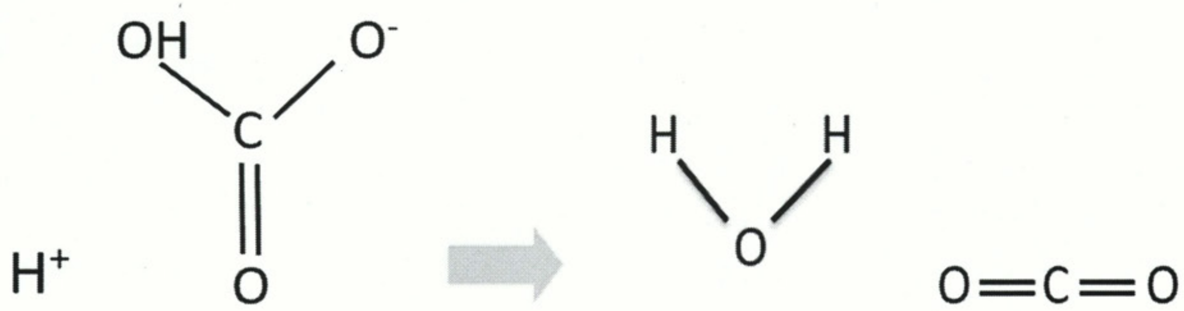
Procedure:

1. Obtain a cup of vinegar and a separate cup of water.
2. Into the cup of water add baking soda (you can choose the amount of each substance you want to use, just make sure to record the amounts).
3. To each cup add a small amount of pH indicator, just enough to produce an obvious and identifiable color.
4. Record the color of each solution.

5. Mix the two solutions together and record your observations. To the mix you may add additional pH indicator if necessary.
6. Try adding additional baking soda and/or vinegar. What happens to the color of the solution as you make these additions?

Vinegar is an acid and baking soda is a base. When you add the two together they will react with each other in a process called neutralization. The vinegar has a low pH and baking soda has a higher pH so mixing the two should result in a solution with a pH somewhere in the middle, closer to neutral, hence the term neutralization. This occurs because the H^+ ions being donated by the vinegar react with the OH^- ions being donated by the baking soda to form H_2O or water, which has a neutral pH. The particular reaction also produces CO_2 which is the gas formed upon mixing.

The reaction is: $H^+ + HCO_3^- \rightarrow H_2O + CO_2$



Conclusions:
1. Was your hypothesis correct?
2. What was the final color of the mixed solution and what does this tell you about the pH?
3. By adding more vinegar and baking soda are you able to get solution to an approximately neutral pH?

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Lab Assistant________________________

Date ______________________

Experiment title ___________________________________

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Chromatography

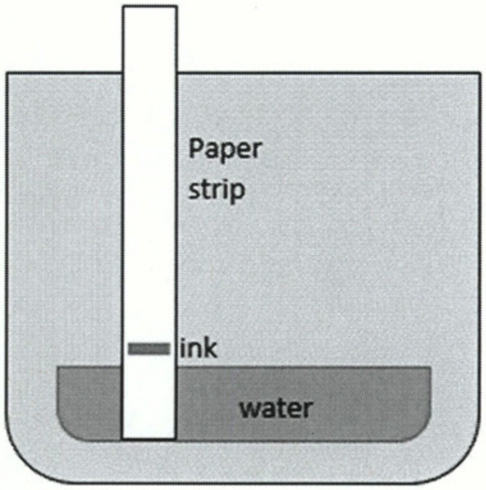
What is Chromatography? The word chromatography originates from the Greek words "color writing" and refers to a chemical method by which a material can be separated into its components. Looking at individual components makes it easier to identify substances.
In chromatography, a sample is placed near the bottom of a chromatography test strip or plate and carried, by capillary action, to the other end of the substrate as the solvent moves. Chromatography separates chemicals based on the size of the molecules and how attracted they are to the solvent. Using a different solvent will often yield different results, even for the same sample being tested. The solvent then, is one of the independent variables which can be altered to yield different results.

Objective: The purpose of this lab is to use chromatography to examine the components of different types of ink and the effect the solvent has on the results.
Various chemicals are used in the dyes depending of the type of ink and to obtain different colors. These chemicals vary from one brand to the next, and chromatography can be used to identify the differences between two types of ink. This method can also be applied to many chemical substances.

Hypothesis: What do you think will happen as the solvent travels up the filter strip? What do you think will be the differences between the different inks and solvents?

Procedure:

1. Obtain at least three different types of ink (markers and ink pens for example, dark ink, like black and purple tend to work best), and a coffee filter, cut into strips.
2. Draw a line with the desired sample about a centimeter from the bottom of the test strip.
3. Place the strip in a glass containing about a half a centimeter of the chosen solvent in the bottom of the glass. Solvents options for this experiment will include, but are not limited to rubbing alcohol, acetone (fingernail polish remover), vinegar, and water.
4. Make sure the strip does not bend. It may be necessary to suspend the strip using a paperclip, string and a toothpick or craft stick. Also, make sure the solvent is not higher than the line of test material, in this case the line of ink.



5. Allow the strip to sit in the solvent for a few minutes. You should be able to watch the solvent travel up the strip. The strip should remain in the solvent long enough for the solvent to travel most of the way to the end of the strip, but do not allow it to completely saturate the strip. Remove the strip when the solvent nears the top of the strip.
6. Repeat this procedure for each of the ink samples with each of the other solvents.

As you perform the experiment make sure to make careful observations and record them in a table, similar to the one below. For this experiment, you should use at least three different samples (such as ink pen, water based washable markers, and permanent markers). Make sure to be specific and detailed when describing the sample in the table. Simply saying "marker" or "pen" may not be specific enough to identify it. Make sure to record the brand of the item and the color, as the results will be slightly different for every sample tested. Remember that you need to be specific enough that someone else could look at your table and recreate the results.

	Solvent A:	Solvent B:	Solvent C:		
Sample 1:					
Sample 2:					
Sample 3:					

Results: Make careful observations. If possible, measure the distance traveled by the solvent and each component of the sample. Include the test strips, or pictures of them, in your lab notebook.

Conclusions:

1. Was your hypothesis correct?
2. What did the results show; did each ink contain the same number and amounts of various substances?
3. How does changing the solvent affect the results?
4. Were any of the solvents more or less effective than others for certain samples and if yes, why do you think this is?
5. What do you think would happen if the test strips were allowed to sit in the solvent for much longer after the solvent had reached the end of the strip?

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Attach Additional Data (tables, graphs, and images) on separate page

Crystal Formation

As a substance cools and turns from a liquid to a solid, or as it settles out of solution, the molecules will often arrange themselves into a regular, repeating pattern that makes it easier for them to bunch together. Substances that form these patterns are said to be crystals, or have a crystalline structure.

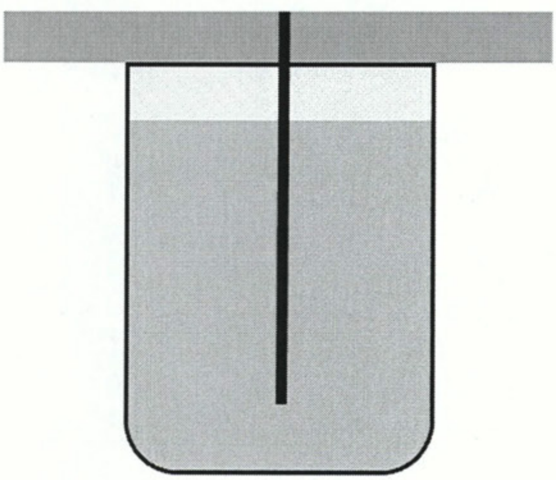
Many of the chemicals in our homes have a crystal structure. This experiment will examine one of these chemicals and allow you to grow your own crystals.

Using safe food chemicals, this lab will allow you to make your own crystals, ones that you can actually eat. Note, it is typically not safe to consume the chemicals used in these experiments and never do so unless it has been specifically stated that it is safe.

Materials: sugar, water, a cup, a craft stick, string or a thin dowel rod, a paper towel

Procedure:

1. Into a pot, add 3 cups of sugar for every 1 cup of water.
2. Heat the solution at medium heat, while stirring, until all, or most, of the sugar dissolves. Do not allow the pot to boil.
3. Pour the warm sugar solution into the cup. If any of the sugar did not dissolve, make sure you do not pour it into the cup.
4. If you are using a string, tie this around the craft stick (or butter knife) then lay it across the top of the cup with the string hanging down, into the solution.
5. If you are using a thin dowel rod simply put it in the solution, allowing it to lean against the side.
6. Put the paper towel (or a coffee filter) over the top of the cup so nothing can fall into the solution.
7. Put the setup somewhere where it will not be disturbed for a few days, and allow it to sit so the crystals can form slowly.
8. Check on the system periodically. If there are crystals forming across the top you can break them off and eat them, if there is a significant amount of crystals forming on the side of the cup you can transfer the entire system into a new, clean cup to encourage the crystals to grow only on your string or dowel rod.



9. Once you can see significant crystal growth, you can remove them from the solution. Set them on a plate to dry.
10. Examine the shape of the crystals you have grown, describe what you can see, and then you may eat the sugar crystals.

You may repeat this as many times as you like. You can try adding a few drops of food coloring and/or a tablespoon of flavor extracts to the solution when you are first dissolving the solution.

This is the same method that method manufacturers use to make rock candy. As the water evaporates, the solution contains a higher concentration of sugar, which is the solute, than the remaining water, which is the solvent, can hold. The sugar must then begin to precipitate out of the solution. The crystals begin to form on the surface of any solid material it comes in contact with, which is why it may be necessary to change cups halfway through the crystallization process and why it is important that any undissolved sugar is not transferred into the cup. Any undissolved sugar that was placed into the cup would have acted as a seed crystal and the majority of crystal which began to grow would have grown on the seed crystal rather than on your string or dowel rod.

Conclusions

1. Did you have crystals growing on the string or dowel rod?
2. Closely examine the crystals, using a magnifying glass if available. Can you see the pattern in the shape of the crystals?
3. Can you think of other compounds that form crystals as they freeze or precipitate out of solution?
4. Describe and sketch the shape of the crystals you have grown.
5. What if you had used salt instead of sugar, do you think the same thing would have happened? Why or why not? Do you think the crystals would have looked the same?

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Lab Assistant__________________________

Date ________________________

Experiment title _______________________________________

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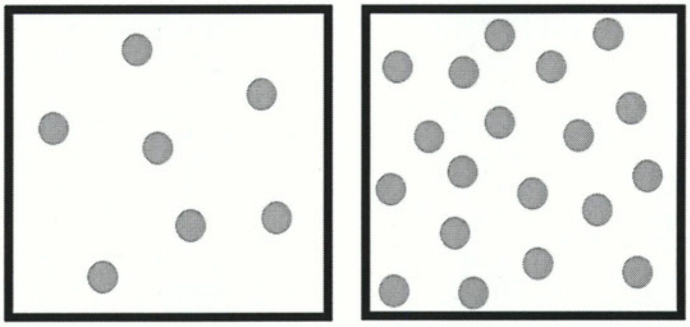
Density

Density is a measure of the amount of mass that occupies a given volume. Materials which are denser will feel heavier than less dense objects of the same size. The pictures below demonstrate the idea of density. The boxes are the same size yet they have a different number of molecules inside them. The molecules in the box on the right are packed more tightly together. This material, therefore, is denser than the material represented by the left box. Think of a block of wood and a block of metal that are the same size, the metal will weigh more because it is denser.



This experiment will demonstrate the density of various everyday objects and liquids.

Needed for this experiment: a tall clear container with smooth sides (like a large drinking glass or a flower vase with smooth sides), turkey baster or small funnel, honey, corn syrup, 100% maple syrup, whole milk, dish soap, water, vegetable oil, rubbing alcohol, baby oil, and food coloring.

Hypothesis: What do you think will happen if liquids of different densities are mixed?

Procedure:

1. Obtain roughly equal amounts of each liquid (a cup or two will be sufficient depending on the size of your container) in separate, clean containers. To both the water and rubbing alcohol, add food coloring for contrast. (Do not use the same color for both liquids)
2. Pour the honey into the container, make sure to pour it directly into the middle, do not let it run down the sides of the container. Allow the layer to settle before continuing.
3. Repeat step 1 with corn syrup and then again with the maple syrup. Add roughly equal amounts of each liquid so the layers will be approximately the same size.
4. Use the turkey baster to slowly add the whole milk to the column, hold the baster directly above the previous layer to avoid mixing, and make sure the liquid does not run down the side of the container, allow the layers to settle before adding the next liquid.
5. Repeat step 4 with the liquid dish soap.
6. Use the turkey baster to slowly add the colored water to the column; hold the baster against the side of the container, directly above the previous layer to avoid mixing, allow the layers to settle before adding the next liquid.
7. Repeat step 5 with vegetable oil, colored rubbing alcohol, and baby oil.

Conclusions:

1. What does this tell you about the densities of the liquids?
2. Knowing that the density of water is 1.0 g/mL, the density of honey is 1.4 g/mL, and the density of baby oil is 0.83 g/mL, estimate the densities of the other layers in the density column.

Investigate Further

Very carefully add objects to the density column to estimate their densities. Try adding a grape or a cherry tomato, an ice cube, ping pong ball, a screw, a game dice, plastic beads, a bottle cap, a popcorn kernel, and/or other small objects. Add the objects gently, to avoid mixing the layers. What do you observe about where each object ends up in the density column. What can you conclude about the density of each object. Record your results in conclusion section of your lab report. Images or sketches of the results can also be attached.

https://www.stevespanglerscience.com/lab/experiments/density-tower-magic-with-science/

Name ____________________

Lab Assistant________________________

Date ______________________

Experiment title ____________________________________

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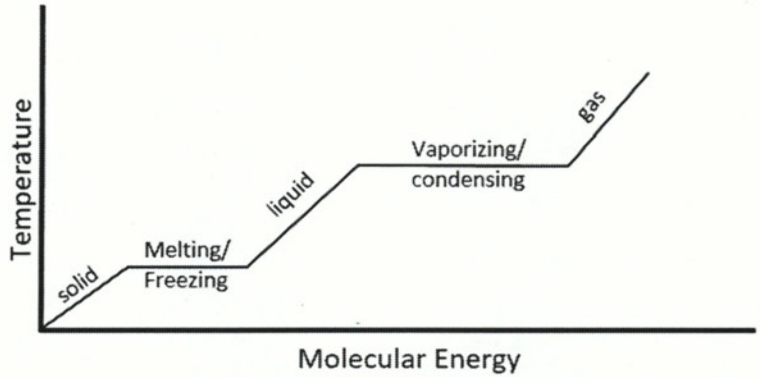
Heat

Temperature is simply a measure of heat, but what then, is heat? What makes something feel hot or cold? Heat is a measure of the kinetic energy (energy of motion) of a molecule. The more energy the molecule has in its movement, the warmer it will feel to the touch.

Molecules are constantly in motion and it is this motion which gives the feeling of heat. The molecules in something that feels cold are simply moving slower. The feeling of heat comes from the molecules of the object you are touching colliding with the molecules in your hand. If the molecules of the object are moving faster than the molecules in your hand, it feels hotter because the molecules in the object transfer some of their energy to your hand. If the molecules of the object are moving slower than the molecules in your hand, it feels cold because the molecules in the object absorb some of the energy from your hand.

When the molecules of a liquid substance lose kinetic energy, or cool, they begin to interact with each other more strongly. Eventually the liquid begins to solidify, or freeze. The temperature at which this occurs is called the freezing point of the substance. Because the state of a substance is dependent on the temperature, a substance cannot exist in the liquid state below its freezing point at a given pressure.



Notice that during the change of state the molecular energy changes but the temperature does not. This is because the change in molecular energy is being used to change the molecular arrangement of the substance rather than change the substance's temperature.

As a substance freezes the molecules arrange themselves into a pattern that allows for tighter compaction. The presence of molecules of another substance can interfere with this pattern of formation and hinder the freezing process, causing the substance to freeze at a lower temperature than it would if it were pure.

To demonstrate this concept, you will need salt, ice and a thermometer. Obtain a bowl of ice, add a very small amount of water, and measure the temperature of the ice water. Now add salt, stir, and take the temperature again.

You should have noticed that the temperature dropped below the normal freezing point of water. This is because the water that is in the solution is being cooled by the ice, but is unable to freeze because the salt particles are hindering crystal formation.

This property is employed by the highway department in the winter, and is the reason they spread salt on the road. Putting salt on the road causes the snow and ice that is already on the road to begin to melt as the salt mixes with the ice and prevents refreezing. The salt also prevents the liquid water from freezing. Spreading salt on the road will not keep the water from freezing completely, it just makes it so that temperatures must be even lower before freezing can occur; for this reason, spreading salt on the road is ineffective if the temperatures drop significantly below the freezing point.

The property can also be exploited to make homemade ice cream. Typically, ice is not cold enough to freeze milk, but adding salt to the ice lowers the temperature sufficiently to enable the ice water to freeze the milk.

Procedure:

1. In a small, resealable bag, mix ½ cup milk or cream, 1 tablespoon of sugar, and ¼ teaspoon of vanilla extract.
2. Place this small bag inside a larger, resealable bag with ice and 5 tablespoons of salt.
3. Shake the entire system for several minutes, you should be able to feel the bag of ice getting colder as the ice cools the water and the water is prevented from freezing by the ice.
4. Check on the smaller bag periodically, when you notice it beginning to solidify you may remove it from the larger bag.
5. Make sure to rinse off the smaller bag before eating the ice cream (otherwise the salt will get in the bag and make your ice cream taste salty).

This ice cream recipe was obtained from: http://science.howstuffworks.com/innovation/edible-innovations/ice-cream3.htm
You may use any ice cream recipe you wish, including adding other flavorings.

Conclusions:

1. Were you able to detect a difference in temperature upon adding salt to the ice water?
2. Explain freezing point depression in your own words.

Name ____________________

Lab Assistant ________________________

Date ______________________

Experiment title ___________________________________

Hypothesis ____

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Pressure, Volume, and Temperature

Pressure can be described as the force a system exerts on another system. Volume is the amount of 3-D space a system occupies. Temperature is a measure of the heat of a system. All three of these concepts are related to and dependent upon each other. Changing one of these factors will affect one or both of the other two factors. When making a change to the system the effect can be calculated using the formula:

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

This experiment will be performed at a constant pressure meaning that $P_1$is equal to P_2 so they will cancel out and the equation that is left is $V_1/T_1=V_2/T_2$. These two factors of the equation are directly related, meaning that increasing (or decreasing) one will force the other to increase (or decrease) as well so that that the overall product remains constant. Use the following math problem as an example: 6/3=12/6. The equation is true but the values are different; increasing one causes the other to increase proportionally.

Hypothesis: What do you think will happen to a balloon if it is placed in a refrigerator?

Procedure:
1. Obtain a balloon and inflate it.
2. Measure the circumference of the balloon with a measuring tape, preferably in centimeters (you will use this to calculate the volume of the balloon by assuming the balloon is a sphere and using the following equation: $V=4/3*\pi*r^3$ where r can be calculated from the formula $C=2*\pi*r$ where C is the circumference you are measuring).
3. Place the balloon in the refrigerator or freezer for a few minutes.
4. Remove the balloon from the refrigerator or freezer and quickly measure the circumference again, before the balloon has time to warm up.

Calculate the initial volume of the balloon (in the equation this will be V_1) and the final volume of the balloon (V_2). Assuming the balloon was initially at approximately room temperature (T_1), which is roughly 23°C, calculate the temperature of the balloon after it had been cooled (T_2). For more accurate results obtain a thermometer that can measure Celsius and measure the temperature of the refrigerator or freezer where you placed the balloon and use the final temperature to calculate the initial temperature.

Conclusions:
1. Was your hypothesis correct?
2. List a few factors that could account for a errors in your calculations.
3. How could you reduce the errors in your measurements?

Investigate Further

Perform this experiment at several temperatures (try putting the balloon in the refrigerator and the freezer for even lower temperatures or carefully heating it with a hair dryer for higher temperatures) and graph the results. What relationship do you notice between temperature and volume? Is this the relationship you expected to see?

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Lab Assistant__________________________

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Experiment title _____________________________________

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Lab Assistant __________________________

Date ________________________

Independent Study title ______________________________________

Hypothesis ____

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Analysis and Conclusions

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Procedure

Data

Analysis and Conclusions

Attach Additional Data (tables, graphs, and images) on separate page

Chemistry at Home

Level 3

IMPORTANT
Note to the Project Helpers

As the project helper for this project you will be the lab assistant. You will be responsible for supervising tasks that may not be suitable for some students (such as using a stove or handling some of the chemicals). None of the experiments in this book are inherently dangerous but if instructions are not followed properly, they may become dangerous. With that being said, make sure to use your best judgement when dealing with chemicals, for example if a chemical has a strong or noxious odor move the experiment outside or to a well-ventilated area. The results of the experiments will also be safe enough that they will not require special disposal. All chemicals can be poured down the drain and flushed with running water.

When using chemicals, make sure to follow all safety procedures provided by the manufacturers. Some chemicals may be slightly different in composition based on brand so be sure to follow the instructions they provide as all of these differences cannot be accounted for in the design of the experiments.

Safety equipment, especially eye protection, is recommended for all experiments involving chemicals. Some chemicals used may also be irritating to the skin. If contact with any chemicals occurs, follow the manufacturer's instructions for cleaning the area. Typically flushing the area with cold water will be sufficient. Some chemicals may also stain clothes, so a lab coat may also be desired. Alternatively, the students may wish to wear old clothes when performing some of the experiments. It is best to avoid direct contact with the chemicals unless you know it is safe to have contact with them.

The chemicals required for these activities can all be found at a typical grocery store or pharmacy. You should never need to purchase high grade, expensive, or toxic chemicals for the experiments. Some experiments require equipment such as a thermometer, scale, and stopwatch.

For this level, it will also be necessary for the students to keep a lab notebook with their results. In the lab notebook, be sure to record detailed observations of the experiments and notes on activities.

Note to the 4H member

This project will demonstrate a few basic chemistry topics. Each level will cover the same topics in greater detail as you progress.

The activities are divided into sections based on the topics and purpose of the activities. The Introduction section is purely informational and will be useful in furthering your understanding of chemistry itself. The Describing Reactions section examines the reaction process specifically, rather than a chemistry topic. Chemical reactions are the basis of chemistry and therefore it is important to understand what is occurring when chemicals react. The final section is the Experiments section. These are what one typically thinks of when imagining a chemistry experiment.

Each year you will need to complete one activity from the "Introduction" section, one activity from the "Describing Reactions" section, and two activities from the "Experiments" section. You also need to complete one independent activity, this can be something such as an interview of a scientist, an additional experiment that you have found and want to try, a brief research paper, or some other scientific activity.

Topics for the final display project can be any of the activities from the "Describing Reactions" or "Experiments" sections, or from one of the independent study activities you choose to perform. The project display should be a formal report of the experiment and your data. A formal report typically includes each step of the scientific method: the question to be answered (objective of the experiment), research (basic information on the topic, an introduction to the concept), a hypothesis, an outline of the experiment (the procedure followed), an analysis of the data including charts and graphs, and a conclusion (was the hypothesis correct and what you learned from this experiment).

LAB NOTEBOOK

From a scientific standpoint, it is important to always record the results of any scientific inquiry. This insures that others who look at your data will be able to understand the experiment and learn from your data, which helps science, as a whole, move forward.

For this level, you will need a lab notebook. Ideally this is a notebook with lined or grid pages and without perforations, so you do not lose any of your experiment data, though any type of notebook will do for this project. As you complete each activity, record it in your lab notebook. Use complete sentences.

See the following page to more information on what to include in the lab notebook and in the formal reports for the final project.

Your Name

Project Helper's Name

Date

Experiment Title (Be as specific as possible, include both the independent and dependent variable)

Abstract (This is a brief description of the purpose of the experiment; the objective and how it will be achieved)

Introduction (A brief summary of the conceptual knowledge necessary to understand the experiment. Additional relevant information about previously performed experiments should also be included here.)

Experiment (A detailed procedure including all steps taken. Also in this section include all chemicals used and the amounts used. This section should be detailed enough that someone could recreate the experiment using your notebook as the instructions for experiment setup)

Data (Include raw data in charts and tables as well graphs of the interpreted data. If there is too much data to include in this section, you may include it as an appendix at the end of the report)

Analysis (Include trends in the data and an analysis of whether or not the results were expected. Examine the quality of the data.)

Conclusions (Answers to questions from the manual, what you learned from the experiment or connections you made to this or other concepts, and new questions you might have. Also in this section account for your errors: were there places where you can see an error might easily occur and how might you improve this in the future?)

Name ______________________________

Project Helper (Lab Assistant) ______________________________

Goals for this Project:

1. ______________________________
2. ______________________________
3. ______________________________

Did you achieve these goals? How?

1. ______________________________
2. ______________________________
3. ______________________________

Activity	Date completed	Project Helper Initials	Independent Activities
Introduction			Description:
Scientific Method			
Periodic Table			
Vocabulary			
Describing Reactions			Date: Helper Initials:
Signs of a Reaction			Description:
Types of Reactions			
Rates of Reactions			
Experiments			
Acids and Bases			Date: Helper Initials:
Chromatography			Description:
Crystal Formation			
Density			
Pressure, Volume, & Temperature			
Temperature			Date: Helper Initials:

Each year complete:

- 1 activity from the "Introduction" section
- 1 activity from the "Describing Reactions" section
- 2 activities from the "Experiments" section

You also need to complete 1 independent activity each year, this can be an interview of a scientist, an additional experiment that you have found and want to try, a brief research paper, or some other scientific activity.

The Periodic Table

The Periodic Table of elements is an arrangement of the elements that orders them based on atomic number and groups them based on properties.

Atoms are made up of three major pieces: protons, neutrons, and electrons. Protons are positively charged, neutrons are uncharged, and electrons are negatively charged. The number of protons an atom has determines which element it is and is called its atomic number. For an uncharged atom, the number of electrons will be equal to the number of protons. The number of neutrons varies but is typically close to the number of protons. Atoms with the same number of protons but different number of neutrons are isotopes of the same element.

Atoms make up all matter so every substance is a specific arrangement of the elements on the periodic table. This activity will give you the opportunity to learn more about the periodic table.

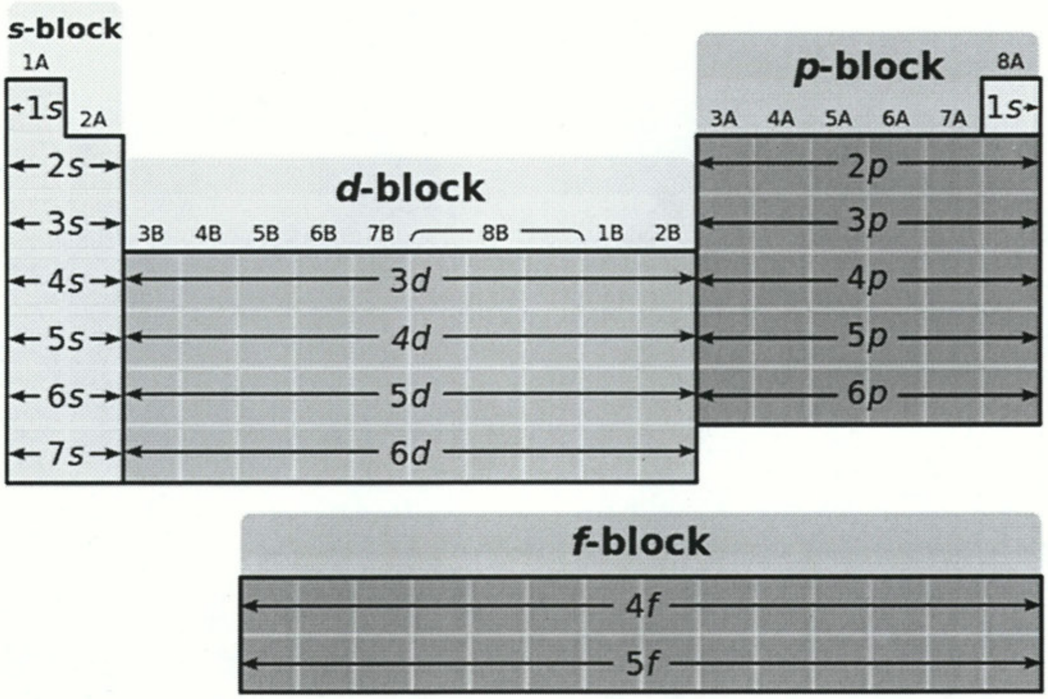
The elements in the periodic table are arranged in a very specific way to relay a great deal of information. Not only are the elements listed in order of increasing atomic number, they are grouped based on the number of electrons in their outer (valence) shell.

Electrons surround the nucleus in what is called the electron cloud. But unlike a cloud, the electrons stay grouped in specific layers (shells) around the nucleus and are paired in orbitals. An orbital will always hold 2 electrons, but the number of orbitals is different for each subshell. The first type is the s subshell, and it contains only one orbital. The next type is the p subshell; it contains 3 orbitals. Next is the d subshell, it contains 5 orbitals. The final type is the f subshell which contains 7 orbitals.

Each layer or shell of electrons adds a new layer of subshells, causing the atom to grow bigger, like layers of an onion. The first layer of shells contains only an s subshell. The next layer contains an s and p, the third has an s, p, and d, and the fourth has all four subshell types. Due to overlapping and complexity, however, the shells do not always fill in numerical order. The fill order for the orbitals is: $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$, $4s^2$, $3d^{10}$, $4p^6$, $5s^2$, $4d^{10}$, $5p^6$ and so on. The first number indicates the shell, the letter is the sublayer, and the exponent is the number of electrons in that sublayer. Notice that the 4s orbital fills before the 3d orbital. The elements are arranged so that this order can be read from left to right across the periodic table, as shown below.

Atoms are most stable when a shell is either completely full, completely empty, or exactly half full. A filled outer shell will result in what is called a noble gas configuration. Noble gases are incredibly stable (unreactive) because their outer shells are completely filled.

An element's location in the periodic table gives you clues as to the number of electrons it has in its outer shell. For example, an element in column 5A would have 5 electrons in its outer valence shell; 2 in s orbitals plus 3 in p orbitals. You can see this in the periodic table because column 5A is the third column of the p-block. This element would be fairly stable because the s subshell is full and the p subshell is half full. It could only be made more stable by gaining 3 more electrons, which would completely fill its outer shell. However, gaining or losing only 1 or 2 electrons would destabilize it.



The stability of the shells is the reason elements column 7A typically have a -1 charge; they favor gaining an electron in order to fill, and thereby stabilize, the outer shell.

Using the order of orbital filling and a periodic table, complete the electron configuration for the following elements.
Ex.: Lithium is $1s^2$, $2s^1$ and Iodine is $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$, $4s^2$, $3d^{10}$, $4p^6$, $5s^2$, $4d^{10}$, $5p^5$

Nitrogen ____
Magnesium____
Aluminum____
Sulfur ____
Calcium____
Iron ____
Gold____

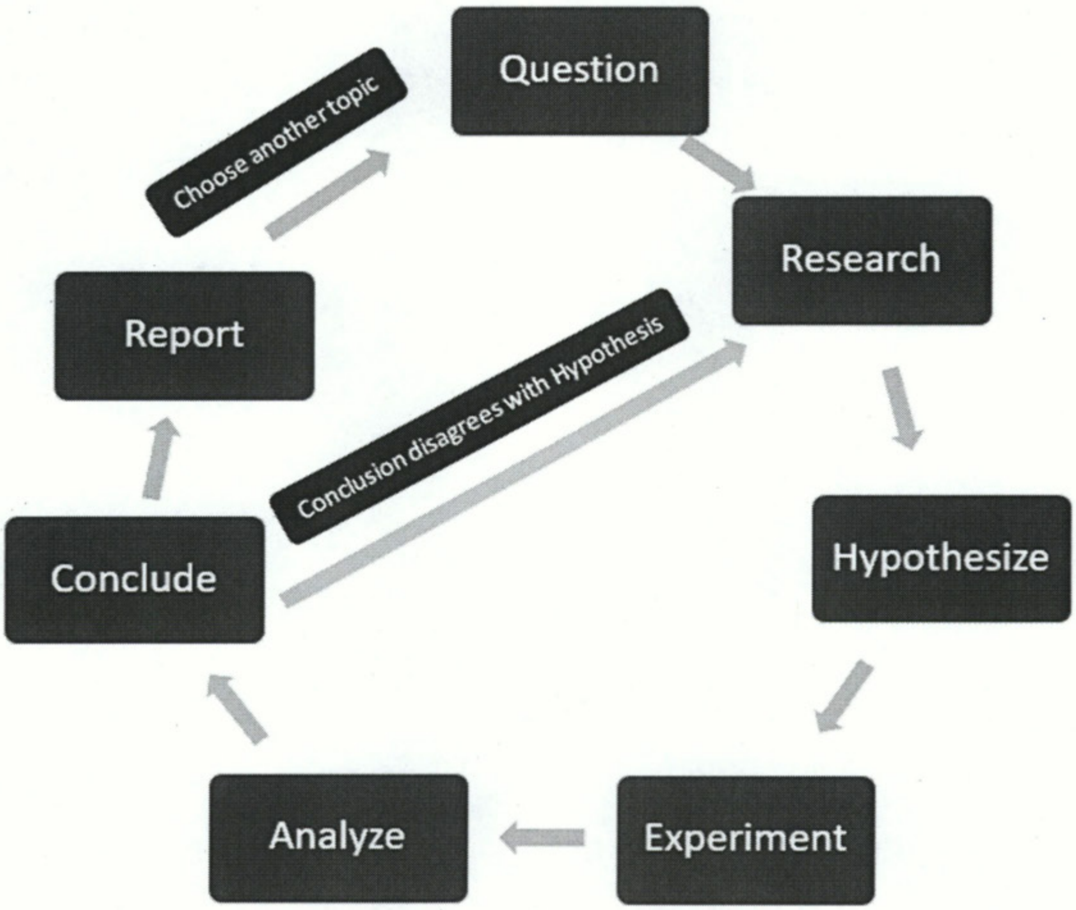
Based on the electron configuration decide if each atom is stable in its natural state, or if it would be more stable if it were to gain or lose an electron. Then, for the first five, predict the charge you would expect each to have in order to be most stable. Write the new electron configuration for the ionized forms of the first five elements listed above.

Scientific Method

As you experience the world around you, you use aspects of the scientific method to understand the information you perceive. The scientific method is a powerful tool for exploring new concepts or well-known concepts more in depth to obtain a better understanding.

The scientific method is a method of approaching a problem. It need not be exclusive to only science. Nearly all academic subjects are interconnected in some way and so the methods we use to understand them are also connected.

Use the scientific method to explore a topic of interest to you. Can you design an experiment to test a hypothesis? This could be the use of trial and error to test a mathematical theory or predicting patterns in literary works.



For this activity, all you need to do is ask a question;

1. Choose a topic you want to explore more in depth than you previously have.
2. Learn as much about the subject as you can.
3. Based on your research, make a hypothesis about possible patterns.

4. Test your hypothesis.
5. Analyze the results of that test.
6. Did the results coincide with your hypothesis; were these the expected results?
7. If yes, share your findings with others and see if they can draw additional conclusions, maybe they can help you see additional patterns or maybe they will raise additional questions that can start the process over.
8. If the conclusion was not what you expected, do more research and see if you can form a new hypothesis that accounts for the variation from what you expected. One major aspect of science is being able to reproduce results. If the results cannot be recreated, other scientists cannot further study them, and will likely be considered unsupported or unreliable. To be able to determine that your hypothesis was correct, it must be able to produce predictable results when tested.

It is important to make very detailed observations during your experiment. To practice this, carefully light a candle and record 25 observations as the candle burns. These observations can be quantitative or qualitative and can reflect both physical and chemical changes. The purpose of this activity is only to practice good observational skills. Perform this practice with your lab assistant, see who can come up with the most observations and compare the observations that you make. How do different people record the same observations? What does this tell you about the importance of careful observation? Then, classify your observations as qualitative or quantitative, and physical or chemical changes. How is each type of observation useful to the examination of experimental data?

Vocabulary

Briefly read the following definitions then create a visual representation of 15 of the terms. Then explain your visual representation and how they pertain to the definition to someone else. Explain the term in your own words rather than simply reading them the definition.

Additionally, use this list as a glossary for other activities.

Acid: a substance which releases H^+ ions or accepts electrons when in aqueous solution.

Atomic Mass (or mass number): the mass of an atom, approximately equal to sum of the number of protons and neutrons.

Atomic Number: the number of protons in an atom.

Base: a substance which accepts H^+ ions, releases OH^- ions, or donates electrons when in aqueous solution.

Chromatography: a method of separating a substance into its components by passing it through a medium so that the individual components will travel at different speeds and be separated by their own movement.

Combustion: A reaction in which a reactant is burned in the presence of oxygen gas to produce water and carbon dioxide.

Conductor: A material which conducts heat and/or electricity.

Decomposition: A reaction in which 1 reactant is broken down into 2 products: $AB \rightarrow A + B$

Density: equal to mass of mass divided volume, the amount of mass that occupies a space.

Electron: negatively charged particles which surround the nucleus of atoms.

Element: a substance which cannot be chemically converted or broken down to another substance. Each element is defined by the number of protons in its nucleus.

Endothermic: a reaction for which the products are at a higher energy than the reactants, a reaction which must absorb energy overall.

Equilibrium: a reaction state in which the rate of product production is equal to the rate of the reverse reaction converting the products back into reactants. The reaction will have appeared to have stopped, but the molecules are always in motion and therefore always transforming.

Exothermic: a reaction for which the products are at a lower energy that the reactants, a reaction which has an overall release of energy.

Hypothesis: a conjecture, inference, or theory based on background knowledge but which has not yet been tested or proven.

Insulator: A material which will not easily conduct heat and/or electricity.

Ion: an atom that has lost or gained an electron and therefore carries a charge.

Isotope: atoms of an element that have different number of neutrons.

Kinetic energy: the energy of motion.

Mass: the amount of matter that makes up an object or substance. Si unit is grams.

Mixture: a combination of two or more substances with all pieces being visible; example sand in water or salt and pepper.

Neutron: neutral particles in the nucleus of atoms.

Nonpolar: Describing a molecule which is symmetrical and has a balanced, even distribution of electrons.

Polar: Describing a molecule which has is asymmetrical or has an uneven distribution of electrons.

Pressure: the force exerted on an object by another object with which it is in contact. SI unit is Pascals.

Products: the ending or produced substances of a chemical reaction.

Proton: positively charged particles in the nucleus of atoms.

Rate of reaction: speed at which a reaction occurs, speed at which reactants are consumed or products are produced.

Reactants: the starting substances of a chemical reaction.

Redox: A reduction and oxidation reaction, a reaction involving an exchange of electrons.

Replacement: A reaction in which one part of a reactant is exchanged for a different piece: $AX + BY \rightarrow AY + BX$ or $AY + X \rightarrow AX + Y$

Solute: in a solution, the substance which is being dissolved, the substance which is present in a lesser amount.

Solution: a combination of two or more substances with the appearance of being only a single substance, no reaction is occurring; example, salt dissolved in water.

Solvent: in a solution, the substance which is doing the dissolving, the substance which is present in a greater amount.

Synthesis: A reaction in which 2 reactants combine to make a single product: $A + B \rightarrow AB$

Temperature: a measure of heat. SI unit is Kelvin (kelvin units are equal to Celsius + 273).

Volume: the amount of 3-Dimensional space something occupies. SI unit is cubic meters.

Rates of Reactions

Some chemical reactions occur very quickly, such as the reaction between vinegar and baking soda. Others take much longer, such as the rusting of a nail. Many things affect the speed of a reaction. Some of the biggest factors in reaction speed are temperature, surface area available for the reaction to occur, and the concentration of the chemicals being used.

This experiment will examine the relationship between chemical concentration and reaction rate. The speed of reaction is dependent on the concentration of the reactants because with greater amounts of reactants present there are more opportunities for collisions between atoms to cause a reaction.

Chemicals necessary for this lab: Vitamin C tablets, Hydrogen peroxide, Liquid laundry starch, Tincture of iodine (available at a pharmacy or grocery store)

Procedure:

1. In a clean container, dissolve a Vitamin C tablet in 2 oz of water. This will be the stock solution of Vitamin C.
2. In a separate container, mix 2 oz of water, 3 teaspoons of hydrogen peroxide, and ½ teaspoon of liquid starch, label this “Solution A”. Prepare a total of 4 of these “A” solutions, each in a separate container.
3. In another separate container, measure out 2 oz of water, remove one teaspoon of water, label this “Trial 1”.
4. Into “Trial 1” add 1 teaspoon of the Vitamin C stock solution and 1 teaspoon of iodine.
5. Mix Solution A with the trial mixture and start a timer.
6. You will be able to tell the reaction is complete when you see a noticeable color change. Record the length of time required for the reaction to complete.
7. Repeat steps 3 through 6 removing 2 teaspoons of water and adding 2 teaspoons of Vitamin C stock solution in steps 3 and 4. Label this trial 2.
8. Repeat these steps again with 3 and 4 teaspoons replaced with 3 and 4 teaspoons of vitamin C stock solution. Label these trials 3 and 4. The purpose of removing water is to maintain a constant volume for each trial. Maintaining consistency in as many aspects of the experiment as possible allow close observation of a single variable. Record the results in a table similar to the one below.

Trial:					
Time:					

Graph the results (convert the time to seconds). What trend do you see in the data? If necessary you can repeat the reaction as many times as you like, steadily increasing the concentration of the Vitamin C added. For an even greater concentration you can dissolve two Vitamin C tablets in 2 oz of water when creating the stock solution.

Reaction explanation:
In this reaction system, there are actually two reactions which are in competition. The reactions produce two different forms of Iodine, the elemental form which is blue or black in the presence of starch (you can test this by combining a few drops of the iodine tincture with a few drops of the starch, or by putting starch in the solution A containers instead of the trial solution containers), and the ionized form which is clear in the presence of starch. The reaction which forms the ionized iodine is much faster than the reaction which forms the elemental iodine so initially it is the dominant reaction occurring, which is why the reaction is clear. Eventually, however, this reaction is completed and the ionized iodine is now free to react to form elemental iodine which will then cause the solution to turn a dark blue.

The two reactions taking place are:
$2I^- + H_2O_2 \longrightarrow I_2 + H_2O$
This is the slow reaction which produces elemental iodine, which is blue in the presence of starch.

and

I_2 + Ascorbic Acid $\longrightarrow 2I^-$ + dehydroascorbic acid
This is the fast reaction which produces the negatively charged iodine which is clear in the presence of starch. After this reaction is complete the charged Iodine, called Iodide ion, is free to react with the hydrogen peroxide.

Conclusions:
1. What was the relationship between concentration and reaction speed?
2. Can you think of any other factors that might have caused or could cause the reaction speed to increase?
3. For a more accurate graphical representation of the relationship between concentration and reaction rate, calculate the concentration of the vitamin C in each of the trials. You will need to first calculate the concentration of the stock solution and then use the dilution formula.

Investigate Further
How do you think changing the concentration of the other reactants would affect the reaction?

http://imaginationstationtoledo.org/educator/activities/iodine-clock-reaction
http://chemistry.elmhurst.edu/demos/TickTock.html

Signs of a Chemical Reaction

A big part of chemistry is studying the way two different substances interact, called a reaction. Sometimes it is easy to tell when a chemical reaction is occurring. Other times it is more difficult. A chemical reaction is one in which the molecules of the substance are changed in some way, whereas a physical change may appear to change the substance in some way but the molecules making up the substance are still the same. For example, tearing a piece of paper is a physical change, but burning a piece of paper is a chemical change.

In this experiment, you are going to perform a simple chemical reaction in order to observe one of the most notable ways to tell a chemical reaction is occurring: gas formation.

Procedure: Simply place a raw egg (or hardboiled for slightly less likelihood of a mess) into a bowl filled with enough vinegar to completely submerge the egg.

Hypothesis: What do you think will happen to the egg?

After the egg has been sitting in the vinegar for some time, you should be able to see signs of the chemical reaction which is occurring between the shell of the egg and the vinegar. Slowly, small bubbles will start to appear on the shell of the egg.

These bubbles are carbon dioxide which is produced as the vinegar is reacting with the calcium carbonate in the egg shell. Eventually the vinegar will react with all of the calcium carbonate, leaving only a thin, flexible coating, called a membrane, around the rest of the egg.

After most of the bubbling has stopped, you can remove the egg from the vinegar.
These bubbles are signs of a chemical reaction. A solid and a liquid have been put together to form a gas. This does not mean, however, that every time bubbles form a reaction is taking place. For example, when water boils, bubbles can be seen, but these bubbles are simply water being transformed into its gas form. A substance changing from a liquid to a gas is not a chemical reaction as long as the substance itself has not changed. Water in the gas form, typically called water vapor or steam, is still water, and will return to its liquid form if it cools down. This also applies to freezing and thawing. Ice is still water, just in its solid form, so freezing water or melting ice are physical changes, not chemical reactions.

In this reaction, however, the chemicals were reacting to form a different substance. A chemical change requires the breaking or forming of chemical bonds while a physical change does not.

The chemical reaction occurring in this experiment is:
$CH_3COOH + CaCO_3 \longrightarrow CO_2 + H_2O + Ca(CH_3COO)_2$

In simple terms this is:
Vinegar + calcium carbonate in eggshells chemically changes to produce carbon dioxide + water + a white precipitate (calcium acetate)

A precipitate is a solid that settles out of a solution, typically after a chemical reaction, and therefore is often another sign of a chemical reaction. Because the amounts are small, it may be difficult to see the precipitate in this experiment. If the solution appears to be slightly cloudy, allow the setup to sit for a while before cleaning up, which will allow time for the solid to sink to the bottom of the container.

Conclusions:

1. Was your hypothesis correct?
2. Can you think of other things that show that a reaction is occurring?

Acids and Bases

A molecule is considered acidic if it donates, or readily gives up, hydrogen ions, H^+. A molecule is considered basic if it donates OH^- ions or accepts the H^+ ions donated by an acid. Many of the things that surround us are acidic or basic to a certain degree. The level of acidity or basicity is determined by the concentration of H^+ ions in the solution. A solution which contains a high concentration H^+ ions is acid, one that contains a low concentration of H^+ ions is basic, and one that contains a concentration of H^+ ions that is roughly equal to the concentration of H^+ ions in pure water is neutral, meaning neither acidic nor basic.

This lab will explore the topic of acid rain and its causes.

The first step of the experiment is to create an indicator solution that will demonstrate the pH of the solution. The pH of a solution is a measure of how acid the solution is. Solutions with a pH of 0-6.9 are acidic, with 0 being the most acidic and 6.9 being almost neutral. Solutions with a pH of 7 are neutral; pure water has a pH of 7. Solutions with a pH of 7.1-14 are basic, with 7.1 being almost neutral and 14 being the most basic.

An indicator will change color depending on the pH of the solution it is in. The indicator for this experiment will be made with red cabbage juice.

Indicator Preparation Procedure:

1. Cut a few red cabbage leaves into small pieces.
2. Boil the red cabbage leaves in a pot of water on the stove for several minutes, until the liquid is a dark purple. It may be necessary to add more cabbage leaves if the color is too dull. Have your lab assistant help with using the stove and handling the boiling water.
3. Strain the leaves out of the juice.
4. The purple juice that remains is your indicator solution and should be put in a bottle and labeled.

For this particular indicator, an increasingly red color indicates the solution is acidic while an increasingly blue to green color indicates the solution is basic. There are many different kinds of indicators and each one will be different colors at different pH's.

Once the indicator solution has been prepared, you can begin the experiment.

Procedure:

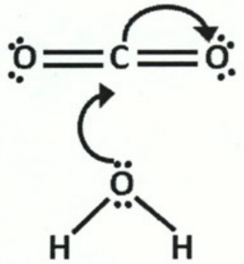
1. Obtain a cup of water and a straw.
2. Add pH indicator, enough to obtain a dark enough color that you will be able to detect changes in color.
3. Using the straw, blow bubbles in the cup of water with indicator solution for a minute or two.
4. Observe the color of the solution, add more indicator solution if the color is too subtle to see changes.

Conclusions:

1. Were you able to observe a color change?
2. Did the solution become more acidic or more basic?
3. Why do you think this happened?

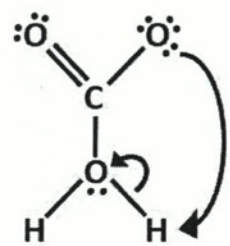
The reaction which causes this change occurs between the carbon dioxide you produce as you breath and the water. The carbon dioxide molecules combine with the water molecules to form molecules of carbonic acid, which, when dissolved in water, will release H^+ ions, decreasing the pH (increasing the acidity) of the solution.

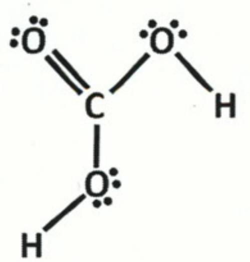
The following diagrams show how the reaction occurs, the dots are free, unbonded electrons, the lines represent a bond between two atoms. These bonds are formed by the sharing of two electrons. As with all chemical reactions, the breaking and forming of bonds involves a movement of electrons. This electron movement is shown by the curved arrows.



In the first step of the reaction the free electrons on the oxygen bond with the carbon, forcing one of the carbon oxygen bonds to move because elements without a d subshell of electrons cannot have 10 valence electrons (see the periodic table activity to learn more about valence electrons).

This places a high density of negative charge on the oxygen which was already bonded to the carbon and a very low density of negative charge on the carbon which is newly bonded to the carbon. The exchange of hydrogen balances this uneven electron density, giving both oxygen atoms 5 valence electrons, which, in turn gives it an oxidation number of 0 because this is the number of valence electrons an uncharged oxygen atom would normally have.





The final product is called carbonic acid. The hydrogens on the oxygen atom can be donated, giving the compound its acidic properties.

Investigate further

Collect samples of rainwater the next several times it rains, and use your pH indicator solution to test the acidity. Is the rain in your area acidic? Because acid rain is caused by increased levels of acidic pollution such as carbon dioxide, sulfur dioxide, and nitrogen dioxide from car exhaust, it is most common in polluted areas and less common in areas with large amounts of trees and other plants. What do the results of your experiment tell you about the pollution levels in your area.

Chromatography

What is Chromatography? The word chromatography originates from the Greek words "color writing" and refers to a chemical method by which a material can be separated into its components, aiding in identification.

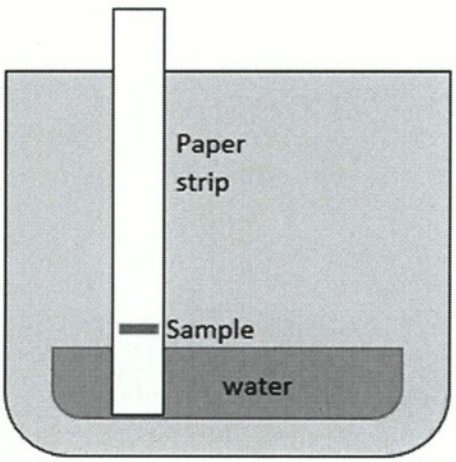
In chromatography, a sample is placed near the bottom of chromatography test strip or plate and carried as the solvent moves, by capillary action, to the other end. Chromatography separates chemicals based on their affinity for the solvent. Therefore, using a different solvent will often yield different results, even for the same material being tested. The solvent then, is one of the independent variables which can be altered to yield varying results.

Objective: The purpose of this lab is to use chromatography to examine the components of plant leaves. Plants contain Chlorophyll, a key substance in photosynthesis and the chemical responsible for the green color of plants. Chlorophyll can be separated from the other substances in a plant leaf using chromatography. The results give clues as to the amounts of chlorophyll in different types of plants.

Hypothesis: What do you think will happen as the solvent travels up the filter strip? What do you think will be the differences between the different leaves or solvents?

Procedure:

1. Obtain leaves from at least three different plants, and a coffee filter (or other porous paper), cut into strips.
2. Using a hard, smooth object (like the side of a coin or your fingernail) press or scrape the leaf sample in a line across the coffee filter strip about one centimeter from the bottom.
3. Place the strip in a glass containing about a half a centimeter of the chosen solvent. Solvent options for this experiment include, but are not limited to rubbing alcohol, acetone (fingernail polish remover) and water.
4. Make sure the strip does not bend, it will likely be necessary to suspend the strip using a paperclip, string and a toothpick or craft stick. Also, make sure the solvent is not higher than the line of test material, in this case the fluids from the leaf.



5. Allow the strip to sit in the solvent for a few minutes, you should be able to watch the solvent travel up the strip. Allow the strip to sit in the solvent long enough for the solvent to travel most of the way to the end of the strip but do not allow it to completely saturate the strip.
6. Repeat this procedure for each leaf sample using each solvent.

Results: Make careful measurements of how far the solvent and each color traveled. Record this distance in centimeters with the line of sample placement as the zero line. Each line represents a different component of the sample. Some samples may have only one or two lines; others may have many separate lines. For each line present record the distance travelled (in centimeters) and the relative abundance (this will be a qualitative, such as thick line or thin line, rather than a quantitative, or empirical value).

Conclusions:

1. Was your hypothesis correct?
2. What did the results show? Did each plant contain the same number and amounts of various substances?
3. Did changing the solvent effect the results?
4. Were any of the solvents more or less effective than others and if yes, why do you think this is?
5. What do you think would happen if you used different plant parts, such as the brightly colored flowers?

Investigate Further

Choose a deciduous (non-evergreen) tree which will be your source of samples, collect samples at many times throughout the year. Use the above method to test the samples at the time of collection and record the results each time. Do you notice any differences in the samples collected at different times of year, such as in spring when the leaves are just starting to grow back and in autumn just before they fall off the tree? What conclusions can you make based on the results?

Crystal Formation

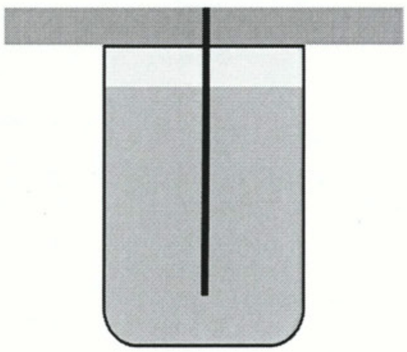
As a substance cools and changes from a liquid to a solid, or as it precipitates out of solution, the molecules will often arrange themselves into a regular, repeating pattern that makes it easier for them to bunch together. Substances that form these patterns are said to be crystals, or have a crystalline structure.

Many of the chemicals in a typical home have a crystal structure. This experiment will examine a few of these chemicals and allow you to grow your own crystals. You will see that different compounds have different crystal shapes.

Materials: epsom salt, alum, salt, sugar, borax, water, cups, craft sticks, string, paper towels

Procedure:

1. Into a small pot, mix water and a small amount of any of the chosen sample. (You may add food coloring if you would like.)
2. Heat the solution on medium heat while stirring, until all, or most, of the solid sample dissolves. Do not allow the pot to boil.
3. Continue adding sample until no more will dissolve.
4. Pour the warm solution into a cup. If any of the sample did not dissolve, make sure you do not pour it into the cup.
5. Tie the string around the craft stick (or butter knife) then lay it across the top of the cup with the string hanging down, into the solution.
6. Put the paper towel (or a coffee filter) over the top of the cup so nothing can fall into the solution.
7. Put the setup somewhere where it will not be disturbed for a few days, and allow it to sit undisturbed so the crystals can form.

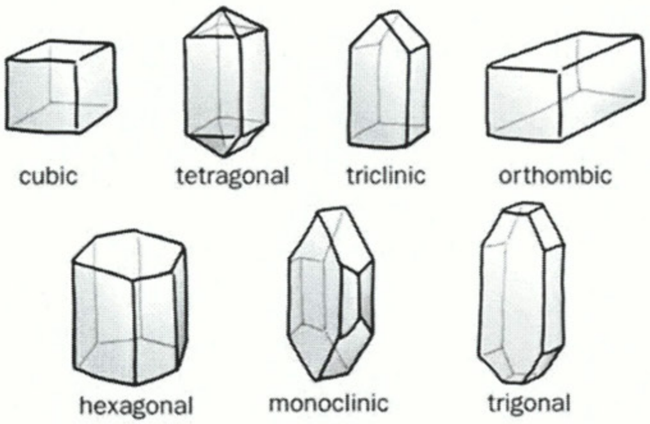


8. Check on the system periodically. If there are crystals forming across the top you can carefully break them off. If there is a significant amount of crystals forming on the side of the cup you can transfer the entire system into a new, clean cup to encourage the crystals to grow only on the string.
9. Once you can see significant crystal growth, you can remove them from the solution. Set them on a plate to dry.
10. Examine the shape of the crystals you have grown. The crystals will be easiest to see if placed on a surface drastically different in color; if no food coloring was added they will show up best on a black surface (such as paper). Each of the crystals should have a slightly different shape. Examine them closely. It may be helpful to use a magnifying glass.

As the water evaporates, the solution contains more sample, which is the solute, than the remaining water, which is the solvent, can hold. The solute is then forced to precipitate out of the solution. The crystals begin to form on the surface of any solid material it comes in contact with. This why it is important that any undissolved sample is not transferred into the cup and why it may be necessary to change cups halfway through the crystallization process. Any undissolved sample that was placed into the cup would have acted as a seed crystal, and the majority of crystal which began to grow would have grown on the seed crystal rather than on your string or dowel rod.

Conclusions:

1. What different shapes can you identify in the crystals you grew? The following are some regular shapes that are often seen in crystal formation.



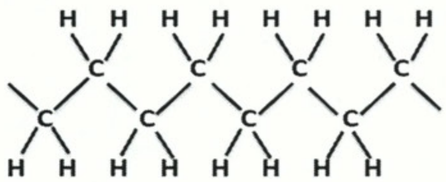
2. Besides the ones you tested, what other substances can you think of that might form crystalline structures?
3. Can you identify crystal patterns in pictures of snowflakes under a microscope?
4. What does this tell you about the crystal pattern of water molecules?
5. Look up pictures of other compounds and elements, such as quartz and bismuth, that form crystals as they solidify. Do you see the patterns these crystals form?

Crystal patterns picture obtained from:
http://easyscienceforkids.com/all-about-crystals/

Density and Polarity

Density is a measure of the amount of mass that occupies a given volume. Materials which are denser will feel heavier than less dense objects of the same size. Think of a block of wood and a block of metal that are the same size, the metal will weigh more because it is denser. Previous activities used oil and water to study density. It was shown that oil would float on water because it is less dense. This experiment also demonstrates the principle of polarity.

The polarity of the molecules is one reason the two liquids did not mix together, and density is the reason one floated on top of the other. The polarity of a molecules is dependent on the symmetry of the atoms and the arrangement of electrons that surround the molecule. If the electrons are evenly distributed, the molecule is said to be nonpolar. If the electrons are more concentrated in one place than another (the electron cloud is denser in this location) the molecule is said to be polar. Polar and nonpolar molecules do not mix because nonpolar molecules are neutrally charged across the entire molecule, while polar molecules have positive and negative charges distributed across the molecule. The distribution of the electrons is dependent on the ability of the individual atoms in the molecule to attract electrons, called electronegativity. An atom that is more electronegative than another atom will better attract electrons so the electron density surrounding this atom will be much greater.

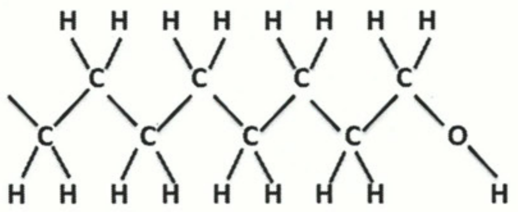


Oil Molecule

Water Molecule

Oil molecules are made of up long chains of carbon with hydrogen atoms branching off the carbon chain. Water is made up of a single oxygen atom bonded to two hydrogen atoms. The difference in electronegativity between carbon and hydrogen is small, so the electrons are evenly distributed in carbon-hydrogen bonds. This molecule is symmetrical and electron distribution is even so the molecule is nonpolar. However, the difference in electronegativity between oxygen and hydrogen is large, so the electrons are unevenly distributed. The electrons are more attracted to the oxygen atom than the hydrogen atoms so the oxygen end of the atom is more negatively charged than the hydrogen end of the molecule. Additionally, the asymmetrical shape of the molecule allows the electrons to concentrate in one area.

1. Obtain a clean container which can be sealed, such as a one pint jar.
2. Add equal amounts of vegetable oil and water until the jar is about three quarters full. Also add a couple drops of food coloring. Notice that the two liquids will not mix. Even if shaken, they will eventually separate again.
3. Add some liquid dish soap and shake the container again, what do you notice now? Soap molecules have both a polar and nonpolar end, which allows the soap to form a bridge between the molecules of oil and water. This is the reason soap works so well for cleaning.



Soap molecule

The OH group on the end is polar and therefore attracted to water, while the carbon chain is nonpolar and so will try to bond with the oil to reduce its exposure to the water molecules. The soap molecule binds to both and allows the water and oil to mix.

To further demonstrate the idea of polarity, try another variation on the density column.

1. Clean out the container you were using, or obtain another clean one.
2. Add equal amounts of water and rubbing alcohol and a couple drops of food coloring (do not fill it all the way up, you will be adding another liquid later). Notice that the two liquids mix and dissolve in each other, they do not remain separated like oil and water.
3. Add salt to the mixture and shake or stir to dissolve the salt. Continue adding salt until no more will dissolve in the liquid. The salt will be more attracted to the water than to the alcohol so saturating the solution with salt will cause the alcohol and water to separate.
4. The two liquids are the same color so it will be difficult to see the separation. Add oil to the mixture and shake it again. As the layers separate you should notice the oil is suspended between two layers. The bottom layer is water, made even more dense by the presence of salt, and the top layer is the rubbing alcohol.

Initially the alcohol and water mixed, because they are both polar, the water more so than the alcohol. Adding salt, however, caused the water to become saturated and denser, forcing it to release the alcohol. The addition of nonpolar oil made it possible to see the distinct layers because it will not mix with either layer.

Conclusion:

1. Explain the concept of density in your own words.
2. Explain polarity in your own words.
3. How does this experiment demonstrate the concepts of polarity and density?
4. Can you think of other ways to demonstrate polarity and/or density?

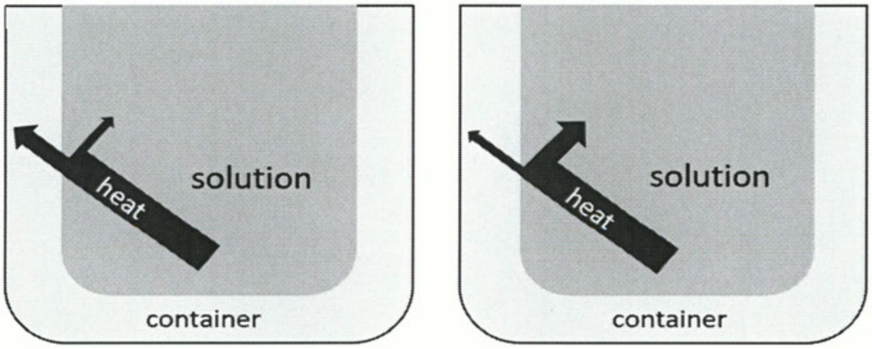
Heat

Temperature is a measure of heat, but what then, is heat? What makes something feel hot or cold? Heat is a measure of the kinetic energy (energy of motion) of a molecule. The more energy the molecule has in its movement, the warmer it will feel to the touch.

Molecules are constantly in motion and it is this motion which gives the feeling of heat. The molecules in something that feels cold to you are simply moving slower. The feeling of heat comes from the molecules of the object colliding with the molecules in your hand. If the molecules of the object are moving faster than the molecules in your hand, it feels hotter because the molecules in the object transfer some of their energy to your hand. If the molecules of the object are moving slower than the molecules in your hand, it feels colder because the molecules in the object absorb some of the energy from your hand.

There are three ways heat can be transferred, because, as with all energy, it cannot be created or destroyed but only transformed. Radiation is heat transfer by light energy such as sunlight. Convection is heat transfer by movement of air or liquid molecules; the high-energy molecules are less dense and therefore rise, as the molecules rise they transfer energy to lower energy molecules, becoming lower in energy themselves and therefore less dense. They then sink unless hit by another higher energy molecule, causing the cycle to repeat until the system reaches equilibrium. The third type of heat transfer is conduction, in which heat is transferred by direct contact. This is the type of heat transfer that occurs when two objects are touching over a significant area. The molecules of one object transfer energy to the molecules of the other object.

This lab will examine the ways in which different objects conduct heat. Objects which easily conduct heat are called conductors and objects which do not conduct heat are called insulators.



The diagram represents conductive heat transfer. On the left, the container absorbs heat from the solution and becomes warmer. This material would be considered a conductor. On the right, the container does not absorb much heat and most of the energy is reflected back to the solution. The degree to which a material absorbs heat can be related to the heat capacity of a substance, which is the amount of energy required to raise one gram of the substance by 1°C.

Hypothesis: Which materials do you think will be the best insulator and which will be the best conductors?

Procedure:

1. Obtain several containers made of different materials. This can include a ceramic mug, a Styrofoam cup, a plastic cup, a metal can, etc.
2. Record the mass of each container.
3. Heat water to near boiling and record the exact temperature.
4. Pour approximately equal amounts of water into each container.
5. Record the total mass of each container, with water, to calculate the mass of water added.
6. Record the temperature of the water in each container periodically (every 15-30 seconds).

Create a graph of temperature vs. time for each container used.

Conclusions:

1. Was your hypothesis correct?
2. Which material was the best insulator? How do you know this?
3. Which material was the best conductor? How do you know this?
4. Describe the exchange of heat for both cases in your own words.
5. How does the steepness of the graph relate to the rate of heat loss?

Pressure, Volume, and Temperature

Pressure can be described as the force a system exerts on another system. Volume is the amount of 3-D space a system occupies. Temperature is a measure of the heat of a system. All three of these concepts are related to and dependent upon each other. Changing one of these factors will affect one or both of the other two factors. When making a change to the system the effect can be calculated using the formula:

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

This experiment will change the temperature of the system, causing first a change in pressure, then a change in volume.

Hypothesis: What do you think will happen if the temperature of the air inside an aluminum can is drastically reduced in a short period of time?

Procedure:

1. Obtain an empty aluminum can.
2. Heat a pot of water to boiling on the stove.
3. Obtain a bowl of ice water.
4. Using a pair of tongs, hold the empty can upside down over the surface of the boiling water (do not submerge the can or fill it with water, you simply want to heat up the air inside the can).
5. Move the can quickly from over the hot water to the ice water bath. Make sure to put the can over the ice water upside down with at least the top submerged so that the water seals the only opening in the can. Make sure you are still using the tongs to hold the top of the can below the surface of the water.
6. Wait a moment for the temperature in the can to reach equilibrium, it should be quite obvious when this occurs and should take less than a minute.

Conclusions:

1. Was your hypothesis correct?
2. What happened to the can?
3. Explain why this happened.
4. Knowing that the initial temperature was approximately 100°C, the initial pressure was 1 atm and the initial volume was the size of the can, are you able to calculate the final conditions for this experiment, especially the volume?